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THE LEAD-CABLE BORER OR "SHORT-CIRCUIT BEETLE" IN CALIFORNIA.[1]

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CONTENTS.

REVIEW OF INJURY TO METALS BY BORING INSECTS THROUGHOUT THE WORLD.

From time to time articles appear in technical journals throughout the world describing injury to metal by boring insects, such injury occurring most commonly in the Tropics. Often the press makes

[1] *Scobicia declivis* Lec.; order Coleoptera, family Bostrichidae.

[2] The authors' names are arranged alphabetically; R. D. Hartman should be credited with the biological studies and most of the experimental tests in California.

much of these accounts, usually in a jocular vein; thus "Bugs" Baer proposed to utilize the lead borer in warf re to eat the helmets off the heads of enemy soldiers, who would n catch cold, influenza, and quinsy from standing bareheaded in a damp trench! With few exceptions the cases recorded are merely accidental and result from the fact that metal blocks the exit of an emerging adult or occurs in the path of a burrowing larva, and they do not constitute direct attacks. In some cases, however, the insects make a direct attack and the resulting injury is serious.

Insects of many different orders are involved. Beetles, or Coleoptera, however, are the more common culprits and include the most injurious species. The families represented are Anobiidae (*15*),[3] Anthribidae (*30*), Bostrichidae (*8*, *30*, *36*, *39*, *41*, *43*, *45*, *48*, *49*, *51*, *52*, *54*), Buprestidae (*47*), Bruchidae, Cerambycidae (*3*, *5*, *9*, *11*, *20*, *21*, *25*, *36*), Curculionidae (*30*), Dermestidae (*4*, *9*, *54*), Lyctidae, Ptinidae (*23*, *31*, *33*, *34*), and Tenebrionidae (*24*). Insects of other orders which have been recorded as injuring metal are members of the family Cossidae in the Lepidoptera (*10*, *14*, *30*), termites or white ants (Isoptera) (*27*, *28*, *37*, *40*, *50*), and the horntail Sirex (*6*, *17*, *18*, *36*, *44*, *55*) and a wasp in the Hymenoptera (*30*, *32*).

Lead is the metal most commonly injured (*1*, *13*, *19*, *35*, *43*, *44*, *45*, *46*, *49*, *53*), such varieties of products having been attacked as lead bullets and cartridges (*7*, *16*, *17*, *18*, *26*), lead (and also tin) roofing (*3*, *5*, *9*, *10*), lead rain gutters, lead stereotype plates (*8*), lead piping for both water and gas (*25*, *47*, *64*, *66*), lead lining of vats, tanks, and cisterns (*15*), the sheet-lead protection for beehives, lead crucibles, lead fuses (*54*), telephone batteries, the lead sheathing of aerial telephone cables (*32*, *38–43*, *48*, *49*, *51*, *52*, *54*), high-tension cables, and lead cables in underground wooden-cased conduits (*27*, *28*, *37*, *40*, *50*), in Australia, Central America, and the United States. A rather interesting type of injury is that to tubular lead telephone fuses (*54*). There is an extensive bibliography in many languages. A portion of this literature is cited under "Insects attacking or penetrating metals," p. 42. Other metals attacked by insects are tin, zinc (actually found in the stomach of the borer) (*21*), silver-plate service (*23*, *31*, *33*, *34*), (quicksilver) lining of mirrors (both in Europe and the United States), and the gilding of chandeliers. Minerals (*4*, *9*), shell or horn, other hard substances (*22*), and inorganic matter (*2*) are also penetrated by insects.

The cosmopolitan ptinid beetle *Niptus hololeucus* Fald. is not only injurious to the quicksilver lining of the backs of mirrors, but also to silver-plate service stored in closets and the gilt on chandeliers.

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[3] Numbers in parentheses (italics) refer to "Literature cited," p. 42. It should be noted that many records referred to in the text have not been published elsewhere.

Another ptinid beetle, *Mezium americanum* Lap., also damages gilded chandeliers, according to Dr. E. A. Schwarz, of the Bureau of Entomology.

A type of injury which occurs fairly commonly is that caused by larder beetles (species of *Dermestes*) to lead telephone fuses.

The most common, extensive, and serious injury to metal by insects, however, is that caused to the lead sheathing of aerial cables; such damage occurs throughout the world and is caused by a great variety of insects (*30*), but the most prevalent and serious injury is that caused by bostrichid beetles.

INJURY TO LEAD FUSES BY INSECTS.

The purpose of the tubular lead telephone fuse is to protect the telephone equipment from heavy currents; the action of the fuse is to melt or "blow," thus "grounding" the objectionably heavy current

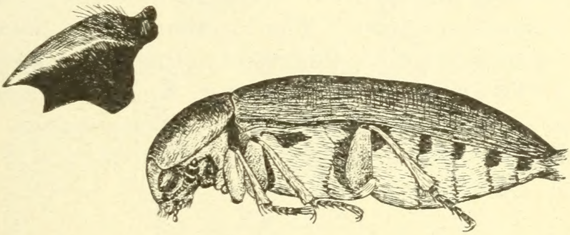

FIG. 1.—The "hide beetle" (*Dermestes vulpinus*): Adult, enlarged 4 times; at left, mandible, enlarged 20 times.

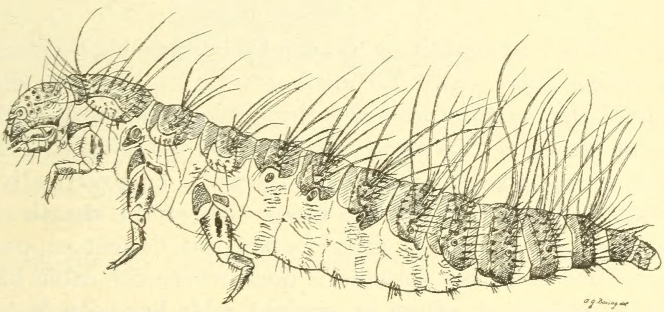

FIG. 2.—Typical dermestid larva (larva of *Dermestes nidum avium*). Greatly enlarged. (After A. Böving.)

and preventing further damage. These fuses are made from paper or fiber treated with zinc chlorid and hardened by subjection to considerable pressure. The wire or tape used in these fuses is chiefly lead, although hardened with the addition of a small percentage of another hardening metal such as tin or antimony. Suitable terminals are provided at the ends of the tube for terminating the fusible conductor. By eating through the lead the insects make it necessary to replace the fuse just as if it had been operated in its regular

function and blown out. The chemically treated fiber tube is not attacked. Both adults and larvæ of the dermestid "hide beetle" (*Dermestes vulpinus* Fab., Fig. 1), have been found in these tubular fuses. The larvæ (Fig. 2) of this scavenger beetle probably enter the fuse to pupate; wood is frequently damaged by larvæ boring through it to form pupal cells; indeed, even asbestos is so penetrated (*4*).

In May, 1910, the Chesapeake & Potomac Telephone & Telegraph Co. reported damage, caused by insects determined as *Dermestes vulpinus*, to fuses in a box at Baltimore, Md. A similar case of this beetle eating fuses mounted in boxes on telephone poles was reported in June, 1910, at St. Louis, Mo., by the American Telephone & Telegraph Co.

The Chicago Telephone Co. reported several years ago damage to a telephone fuse in the Chicago stockyards. The fuse had been cut. An adult and two larvæ of *Dermestes vulpinus* were found in the fuse. The fuse wire had been bored through bit by bit. The adult was an unusually small specimen. The location of this damage in the stockyards is significant, since this insect normally damages hides, etc.

Dr. Wm. Lewis Culpepper, of Syracuse, N. Y., reported in March, 1916, that an insect, determined as *Dermestes vulpinus*, was found eating and destroying the battery in a telephone; *i. e.*, "dry cells" with the shell made of zinc.

DAMAGE TO LEAD SHEATHING OF AERIAL CABLES BY SCOBICIA DECLIVIS LEC.

CHARACTER OF DAMAGE.

Damage to the lead sheathing of aerial telephone cables consists of perfectly round holes about 2.5 millimeters (0.1 inch) in diameter which extend through the lead sheathing from the outer surface to the paper insulation of the wires within. (Pl. VI, Fig. 3; Text Fig. 3.) Cables of various diameters are attacked. In practically every case the hole is made through the lower side of the sheath close to where the suspending ring or metal or marline hanger supports the cable. In a few cases the damage is done where the cable has been scarred or roughened or where an upright cable has been fastened to the poles by clamps. In a number of cases where attempts had been made on the sheathing the work was abandoned before the sheathing was penetrated. In cases where the sheathing is penetrated, moisture is very readily drawn in to the wires and the entire supply of electric current may be short-circuited. If the hole happens to be in the proper location a great deal of moisture enters and the cable may be ruined for 15 to 20 feet. Particularly in case of slack cable or those on grades the moisture sometimes penetrates and soaks the insulation for long distances. This necessitates cutting out the cable, splicing

and insulating the wires, and resheathing, which in a 600-pair cable means considerable skilled labor.[4]

Most of the damage is probably done from June to August, when the beetles are emerging in large numbers. The injury is not apparent, however, until later, after the rains, when the water soaks through and causes a short circuit. Thus usually all the "troubles" come at once.

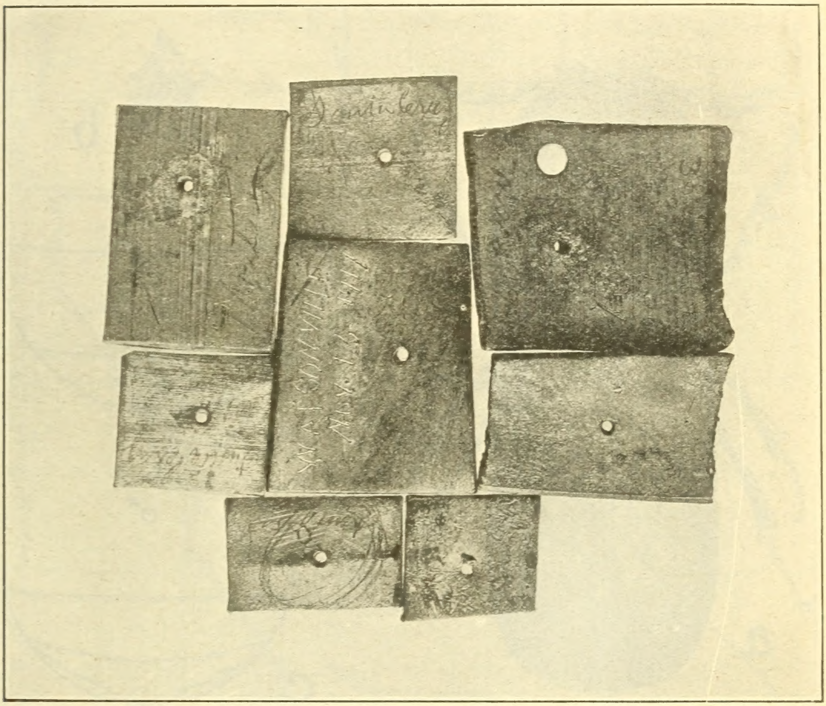

FIG. 3.—Holes bored in the lead sheathing of aerial cables by the California lead-cable borer (*Scobicia declivis*) at various localities in California. Natural size.

OCCURRENCE AND EXTENT OF INJURY TO CABLES IN THE UNITED STATES.[5]

The first report of the boring of cable sheath by insects was received from California in the fall of 1903. It is understood that prior to that time about 100 cases of injury had been experienced over the period of five or six years. The borings occurred adjacent to metal cable hangers, and at first it was thought that the use of mar-

[4] In getting the exact location of and repairing "bug" trouble the linemen travel along the cable on a pulley or sliding seat hung on a messenger cable. Of course the wire trouble or leak is approximately located from the office by means of the "Wheatstone bridge." Injury is remedied by "wiping" a knob of lead on a patch or cutting away the lead and putting on a new joint or "sleeve." Dry holes are merely soldered; that is, where the moisture has not soaked through. (Pl. X, Fig. 1.)

[5] By R. F. Hosford, Engineer, American Telephone & Telegraph Co., New York, N. Y.

line hangers would eliminate injury, but soon reports from other parts of the country demonstrated that this was not so.

In August, 1904, similar damage was reported from Corsicana and Fort Worth, Tex. In the next year boring of cables in the South Atlantic and Gulf States was reported.[6] Damage to cables at Watsonville, Calif., was reported in 1906.

For a number of years following no reports of insect damage were received, probably because the magnitude of the injury was not

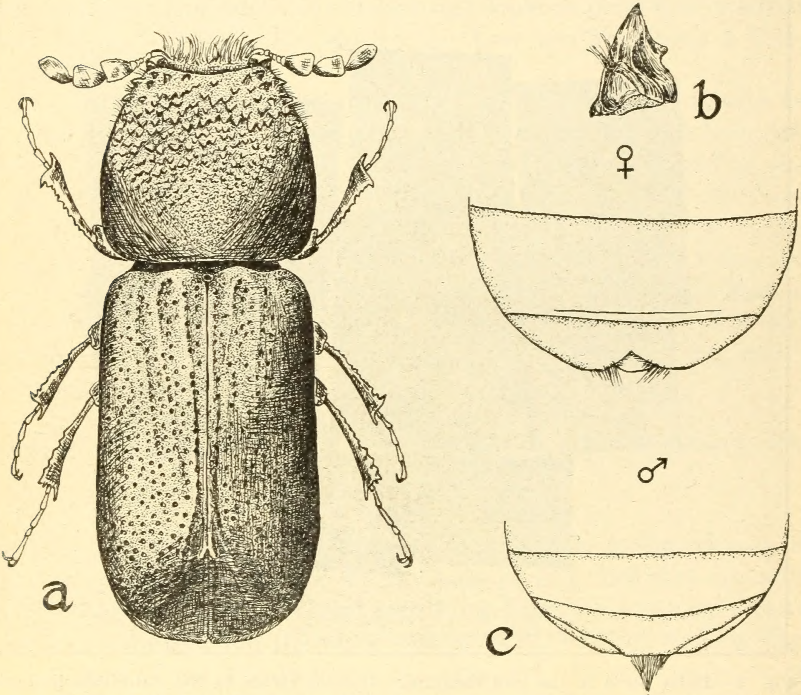

FIG. 4.—The California lead-cable borer (*Scobicia declivis*) : *a*, Adult beetle ; *b*, left mandible of adult beetle ; *c*, sexual differences in adult beetles. *a*, Enlarged 13½ times ; *b*, enlarged 26 times ; *c*, greatly enlarged.

large from a maintenance standpoint and the cause of the injury had been discovered and made known to the plant forces. It appears from data recently collected that trouble was experienced in Brownsville, Tex., in 1912, and in Los Angeles, Calif., in 1913. The insect damage was not, however, large in comparison with other causes of cable trouble. In the year ending March 31, 1916, insect injury was reported as the cause of about one-fifth of all aerial cable trouble

[6] During the same period scattered cases of the destruction of fuses by insects were reported from several States. In these cases several of the beetles causing the damage were secured and identified as *Dermestes lardarius* L.

in southern California. In 1918 insect injury was reported at Galveston and Houston, Tex., six years after the Brownsville case.

By far the greater number of cases of insect injury to the lead sheathing of aerial cables have occurred in California, where the

FIG. 5.—Map showing distribution of trouble caused by the California lead-cable borer.

insect responsible for the trouble is the bostrichid beetle *Scobicia declivis* Lec., *54*. (*Sinoxylon declive*, *56*, *58*, *59*, *60*, *61*, *62*, *63*, *66*, *67*; *Xylopertha declive*, *57*, *65*, *66*, *68*; Fig. 4.) Southern California has been one of its principal centers of activity.

Statistical records have not been kept until recently. The California experience of recent years can be seen from the map. (Fig. 5.)

Cable trouble due to insect boring seems to approach most closely to regularity of occurrence in California, where the districts affected extend along the coast from San Diego to some distance north of San Francisco, although trouble has been reported at points as far inland as Sacramento and Marysville.

The extent of the beetle injury to the lead cables appears to vary considerably during different years. In 1913 it was particularly bad at Marysville, in 1917 at Monterey and Salinas, and in 1918 at Watsonville. Part of this variation may be due to the fact that tallow has been used on some cables. There have been no cases of attack found at points protected by tallow, but the experience has not been long enough to indicate whether this freedom from attack is accidental and due to the absence of beetle attack for the years during which the tallow has been under trial or is actually due to its turning the insect away.

It should be noted that occasionally many holes are found in the same piece of cable and are necessarily taken care of in clearing the one case of trouble. The number of holes may vary from 1 to a span (section of cable between two poles, the distance averaging 100 feet) to 125 to a span. In 1913, 106 holes occurred in one span at Marysville; in 1917, 44 occurred under 44 consecutive rings in one span and 30 under 30 consecutive rings in the following span at Monterey; and in the same year 125 holes occurred in one span at Salinas. As one hole may put from 50 to 600 or more telephones out of use for from 1 to 10 days, the damage is rather extensive.

Cases of cable trouble are also occasionally reported where insects, in making their way out of a wooden pole, strike cable laterals or risers and cut into the sheath. One such case was reported from Kingston, N. Y., in the fall of 1918 and another from Orlando, Fla., in July, 1919. In the latter case cable trouble occurred from wetting by a shower before the beetle had cut its way out and it was caught and identified as *Eburia distincta* Hald. Such experiences as these demonstrate that many wood-boring insects are able to cut cable sheath. (Fig. 6.)

The following are additional records reported to the Bureau of Entomology:

A case of insect damage (bostrichid) to cable occurred at Savannah, Ga., in 1915; another at Galveston, Tex., in 1920, caused by *Xylobiops* sp., probably *basilare* Say.

Among the cases where the identity of the insect causing the injury is in doubt is a report to Dr. F. H. Chittenden, of the Bureau of Entomology, in November, 1906, of small punctures in the lead covering of cables at Watsonville, Calif. These were thought to have

been caused by the dermestid *Perimegatoma variegatum* Horn; more probably, however, the damage was due to *Scobicia declivis*, which has injured cables at Watsonville.

FIG. 6.—Hole accidentally bored through lead sheathing of a cable on a telephone pole by a wood-boring beetle in its efforts to emerge from the wood of the pole. Natural size.

DAMAGE BY THE CALIFORNIA LEAD-CABLE BORER (SCOBICIA DECLIVIS) TO TREES AND FOREST PRODUCTS.

CHARACTER OF DAMAGE.

The usual damage to the wood of trees attacked by the cable beetle is a complete riddling caused by the egg galleries of the beetles and the mines of the larvæ. (Pl. VII, Fig. 3.) When the insects

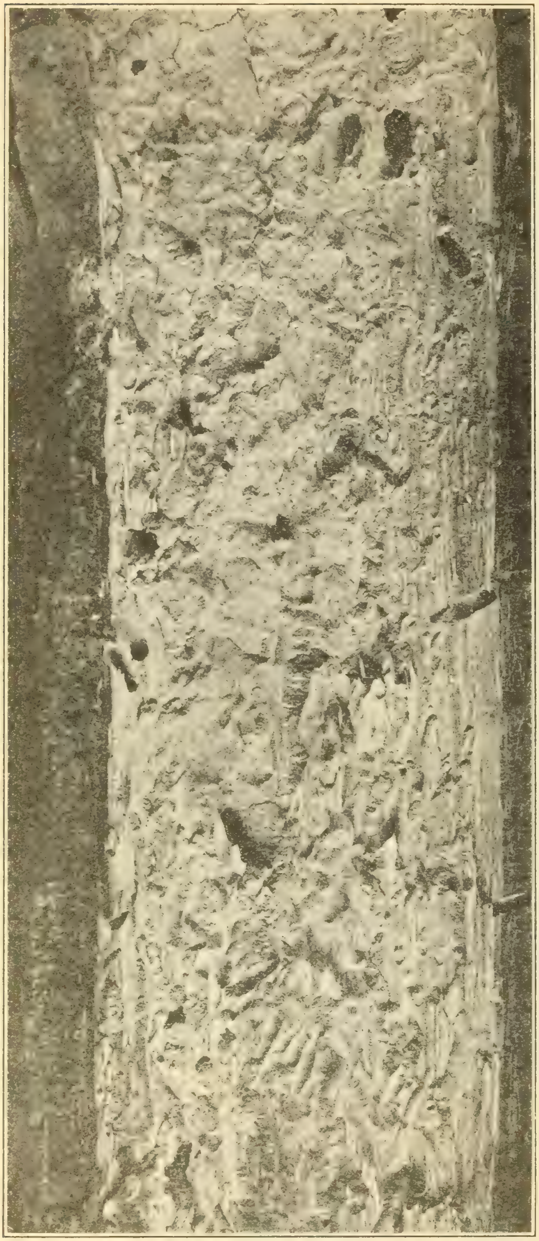

FIG. 7.—Work of the California lead-cable borer in California live oak (*Quercus agrifolia*), Los Gatos, Calif. Note that the wood is "powder-posted." The larger holes were made by a roundheaded borer. Natural size.

are through with a section of wood, nothing remains but the bark and enough solid wood to hold the mines together. All of the rest is reduced to numerous holes (the egg galleries and exit holes) and the winding larval mines closely packed with the meal-like boring dust. (Figs. 7 and 8.)

In special cases the beetles may attack and kill living trees. On September 28, 1919, Mr. Hartman found a cherry tree (*Prunus avium*) in Los Gatos, Calif.. with the foliage fading. Close examination showed numerous small holes in the bark at the bases of the branches and buds and in rough spots on the bark of the trunk. Some of these holes contained Scobicia beetles and many of them were the entrances to galleries which encircled the branch or trunk just beneath the surface of the outer wood. No other cause for the dying of the tree could be discovered. No eggs or larvæ were found.

In the laboratory at Los Gatos, numerous beetles which emerged from the wood stored for rearing purposes entered a cedar cigar box containing large vials of alcoholic speci-

mens. Many entered through the partially closed lid of the box but others bored through the sides. After entering the box the beetles burrowed into the cork stoppers of the vials. Some went through the cork to the alcohol, while others bored between the cork and the glass and stopped. (Pl. IX, Fig. 4.)

FIG. 8.—Exit holes of the California lead-cable borer in bark of California live oak, Los Gatos, Calif. Natural size.

Dr. J. J. Rivers (*62*) reported a number of years ago that the beetles damaged wine casks in California by boring across the grain of the wood to the contents. About this same time D. W. Coquillett (*63*) reported that the species mined orange wood and rosebushes. The reference to rose may refer to *Psoa maculata* Lec., nearly related to *S. declivis*.

EXTENT OF DAMAGE.

The work is very common in most of the oak wood used for fuel in central California. This wood is cut during the summer months when the beetles are flying and is particularly likely to be infested. It has been very little trouble to collect all of the infested wood needed for laboratory rearing purposes at the Los Gatos wood yards during the winter months. Practically every fallen tree of any of the oaks in the forests shows extensive work of this species. Dead or dying elms in the parks or along the highways are likely to be similarly infested. Doctor Rivers (*62*) says that it attacks dry lumber, particularly oak, and especially oaken wine casks, and that it has caused the loss of thousands of dollars to the wine industry. Prof. J. H. Comstock (*60*) also mentions this habit and says that oak, chestnut, pine, whitewood, and eucalyptus casks were used to stop the trouble, but without success.

BIOLOGY OF SCOBICIA DECLIVIS.

DISTRIBUTION.

The insect appears to be widely distributed in California. There are specimens in the Forest Insect collection from Berkeley, Confi-

dence, Hillsborough, Hollister, Lamoine, Los Gatos, Monterey, Nordhoff, Palo Alto, Placerville, Salinas, San José, Santa Cruz, Shingle Springs, Tuolumne, Vade, and Watsonville in California, and Ashland and Hood River, Oreg. Others record it from Cisco, Fort Tejon, Los Angeles, Orange, Pomona, Sacramento, San Nicolas Island, Sonoma, and Sylvania in California. The range in elevation is also great, being from 50 to 5,300 feet.

FOOD PLANTS.

The principal food plants of the cable beetle are the various species of oak. Of these the California live oak (*Quercus agrifolia*) and the black oak (*Q. californica*) appear to be the most important, but heavy infestations have been found in the blue oak (*Q. douglasii*), the white oak (*Q. lobata*), the huckleberry oak (*Q. chrysolepis*), and the tan oak (*Q. densiflora*).

Besides the oaks, the writers have found infestations in the wood of the elm (*Ulmus campestris*), the bigleaf or Oregon maple (*Acer macrophyllum*), the California laurel (*Umbellularia californica*), the sweet cherry (*Prunus avium*), the gum (*Eucalyptus* sp.), and the wattle (*Acacia* sp.). In addition to these, Coquillett (*63*) records the orange and rose as food plants.

ASSOCIATED INSECTS.

The borers commonly associated with the cable beetle in the oaks are the three roundheads, *Xylotrechus nauticus* Mann., *Neoclytus conjunctus* Lec., and *Phymatodes nitidus* Lec., and the powder-post beetle *Lyctus planicollis* Lec. The larval work of the cable beetle usually can be distinguished from the work of the other species because the mines are smaller, circular, and finer than those of the roundheads and larger and coarser than those of Lyctus. (Pl. VII, Fig. 4.) Lyctus also works only in the sapwood. Sometimes the larger powder-post beetles, *Polycaon stoutii* Lec. and *P. confertus* Lec., occur with the cable beetle. The only associate found in the elm is the roundhead *Xylotrechus nauticus*. In the California laurel the common species is the anobiid *Ptilinus ramicornis* Casey, and the cable beetle occurs only in small numbers. The work of the anobiid can be distinguished by the smaller size of the larval mines. The buprestid *Chrysobothris femorata* Oliv. has been reared from infested live-oak wood.

PREDATORY AND PARASITIC ENEMIES.

The predatory and parasitic enemies of the cable beetle do not appear to be very common. One clerid, *Monophylla californica* Fall, is predatory, and one histerid, *Teretrius* sp., may be. The clerid larvæ are found in the mines of Scobicia and of the associated *Lyctus planicollis*. The adult clerids emerge and fly during July and August.

The histerid larvæ appear to be more common in the mines of the Lyctus. The predator *Trogosita virescens* Fab. was reared from infested wood. No Hymenoptera or Diptera were observed in any of the rearings that could be determined as actual parasites of or predators on Scobicia.

LIFE CYCLE.

According to the observations made at the Los Gatos laboratory, the life cycle of the cable beetle is as follows: The mother beetle excavates an egg gallery or burrow in the solid wood and lays her eggs in the pores of the wood from this. (Figs. 10, 14.) The eggs hatch in about 21 days. The larvæ mine in the wood (Pl. III, Figs.

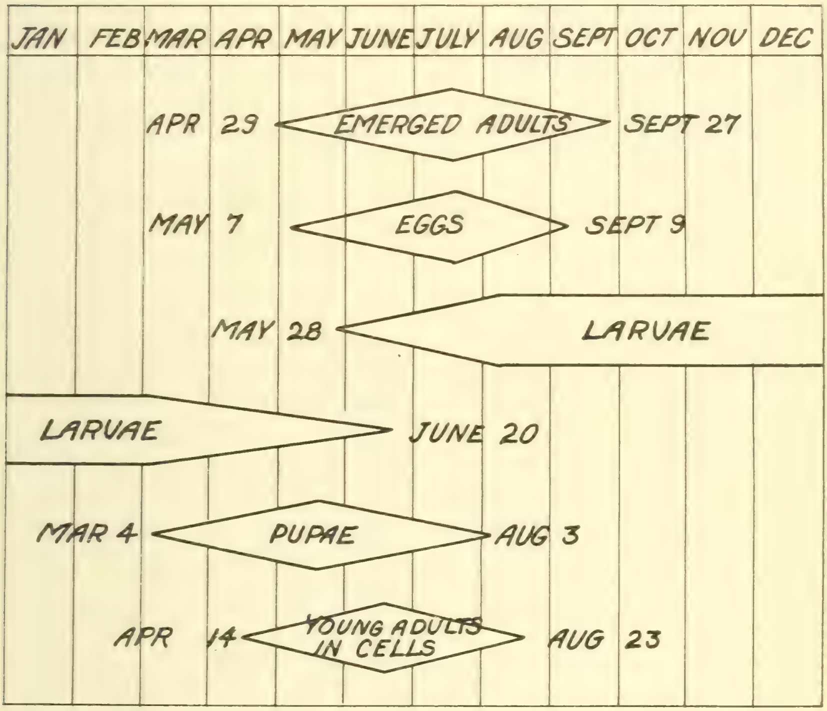

FIG. 9.—Diagram illustrating seasonal history of the California lead-cable borer.

4 and 5) for about nine months, molting about six times. They then become quiet and remain as prepupæ for about six days, whereupon they pupate. The pupa stage lasts for about 14 days and then the transformation to the young beetles occurs. The beetles remain in the wood about 30 days, hardening and maturing. (Pl. III, Fig. 2.) They then eat their way through the outer wood and bark, emerge, and, if females, start new galleries in the same or another section of wood. (Pl. III, Fig. 1.) About the time the galleries are started,

mating occurs (Pl. III, Fig. 3) and the mothers lay their eggs in the wood to start a new generation.

SEASONAL HISTORY.

The lead-cable beetle has only one generation a year. Eggs have been found from May 7 to September 9, larvæ from May 28 one year to June 20 the next year, pupæ from March 4 to August 3, and adults from April 14 to September 27. The beetles are most common in July and August, the maximum emergence being from July 20 to 30. The pupæ are most abundant from May 1 to June 15.

A few pupæ and young beetles were found in their pupal cells in elm in November. Whether these were retarded individuals of the past season's generation or greatly accelerated ones of the coming generation could not be determined.

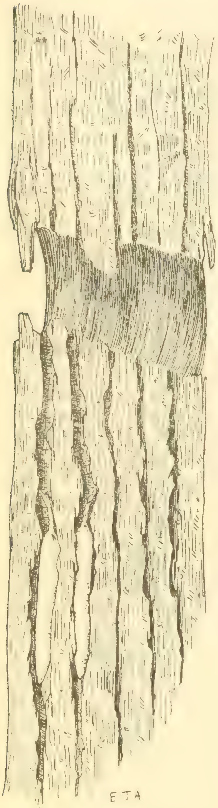

FIG. 10.—The California lead-cable borer: Two eggs in pores of wood near exit hole of adult beetle. Greatly enlarged.

DESCRIPTION AND HABITS.

THE EGG.[7]

Considerable time was spent and patience was necessary in locating and taking notes on the first egg. (Fig. 10.) After the position was found, numerous eggs were ruined in an effort to get them under the binocular, but after a number of attempts it was successfully accomplished. The eggs are very soft, the slightest touch puncturing them, while they quickly shrivel and dry when exposed.

Description.—Egg elongate, about 15 times longer than broad; average length, including stem, 2.1 millimeters; average width, 0.14 millimeter. The end leaving the ovipositor first is rather bluntly pointed, while the end leaving the ovipositor last (or gallery end) has a slender stem attached to it about 0.25 millimeter in length. The egg is somewhat the shape of that of *Lyctus planicollis* Lec., described and figured by T. E. Snyder,[8] yet does not bear any longitudinal striæ. The color when first deposited is pale white, gradually changing to a dull white or cream, the surface being rather dull with a slight granular appearance. The larva occupies about two-fifths of the egg proper when developed, its mandibles showing through the transparent eggshell four to seven days before hatching. The gallery end of egg and stem attachment

[7] The peculiar egg of this beetle was first found by R. D. Hartman.

[8] Jour. Agr. Res., v. 6, no. 7, p. 274–275, pl. 28, 1916.

shrivel considerably before hatching, which takes place on an average 21 days after oviposition.

The Larva.[9]

First stage [10] (Pls. I and II).—In hatching the young larva cuts or tears a hole in the caudal end of the egg with its caudal spine or saw and backs out into the pore of the wood. It then turns around and if the pore at that point is the proper size for it to obtain a leverage it starts mining. If not, it follows down the pore until it does obtain a suitable leverage. During this stage the larva is not curled as in the later stages. After mining a short distance, from 2 to 5 millimeters, it stops and molts to the second stage. The caudal spine is then lost and the curled position assumed.

Later stages.—The mining proceeds parallel with the grain of the wood, the borings being packed into the mine behind the larva. Every so often the mining stops and molting to the next stage occurs. Apparently six molts in all take place before the larva becomes full grown. (Fig. 11.)

Fig. 11.—The California lead-cable borer: Mature larva. Enlarged 8 times.

During the last stages the larva mines deeper into the wood, returning toward the surface just before pupation. It does not mine close to the surface before pupation, however, as do many of the wood-boring roundheads and flatheads, the adults of which are not so able to bite their way through the solid wood.

In mining the larva assumes the usual curled position and braces itself ventrally with its legs, especially with the spurs on the prothoracic pair and with the anal tergite, and dorsally with the thoracic tergites. The head is on a flexible neck and able to move in any direction. The mandibles, by opening and closing laterally, cut the wood into small particles. Some of these are taken into the digestive system, but most are passed down to the legs, which deliver them into the scoop-shaped abdominal sternites. The excrement is

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[9] For detailed description of the larva, by Dr. Adam G. Böving, of the Bureau of Entomology, see Appendix, page 49.

[10] R. D. Hartman discovered the first-stage larva and the fact that Scobicia has different types of larvæ.

also passed into this scoop, the short length of mine between the larva and the packed borings being left open. The mining continues, the larva rolling from side to side, until the abdominal scoop is full of borings. The larva then turns either dorsally or ventrally toward the packed end of the mine and drags the load of borings to it. By thrusting its anal segments forward a number of times it throws the load of borings up to the legs, which pass it on to the mandibles, and these knead it into the mass of borings already firmly packed into the mine.

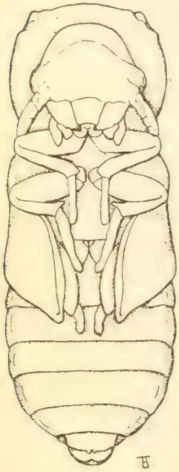

FIG. 12.—The California lead-cable borer: Pupa. Enlarged 8 times.

If a larva is taken from its mine it is unable to travel in any direction it desires. It can wriggle around and roll over and over, but that is about all.

Molts.—A study of the larval mines and cast skins indicates that the larva molts six times before it pupates. The first molt takes place after the larva has mined a distance of from 2 to 5 millimeters from the eggshell, the second from 8 to 15 millimeters, the third from 21 to 33 millimeters, the fourth from 57 to 69 millimeters, the fifth from 130 to 142 millimeters, the sixth from 250 to 290 millimeters, and pupation at about 500 to 580 millimeters.

Prepupal larva.—When the larva becomes full grown it straightens out, becomes shorter, broader, and sluggish, and enters a quiescent stage. No distinct pupal cell is made. The prepupal larval skin gradually turns transparent, showing the pupa within. In about six days the skin breaks at the back of the head and slowly sheds down the head, thorax, and abdomen to the caudal end, where it adheres to the caudal segments of the pupa.

THE PUPA.

The pupa is milk white at first. (Fig. 12.) In from two to four days the eyes and mandibles start to color light brown. The tubercles on the prothorax also are faintly indicated. In from four to seven days the eyes and mandibles have turned dark brown, the prothoracic rugosities a light brown, and the mouthparts, antennæ, prothorax, and legs show some color. In from 10 to 15 days the tubercles have attained the normal black of maturity, the mouthparts, antennæ, and legs have become light amber, and the tibial teeth and spurs dark brown; the prothorax has changed to brown, the abdominal sternites to a light brown, and the abdominal tergites

have started to color. The wing pads now commence to swell and on about the fifteenth day from pupation the struggles of the insect split the pupal skin, the wings and elytra spread over the dorsum of the abdomen, and the transformation to the adult has taken place.

The Immature Adult.

At first the elytra of the young beetle are dull white and rather soft and the small punctures very distinct. The elytra slowly color to light brown, dark brown, and finally black. The abdominal segments also blacken, and in about one month or six weeks the beetle appears full grown. It slowly bites its way to the surface of the infested section and some warm day emerges as a fully matured beetle. (Fig. 4.)

The Mature Adult.[11]

General description.—Form cylindrical, head deflexed; size small (average length, 5.85 millimeters; average width, 2.10 millimeters); the prothorax and abdominal sternites about equal in length. Color dark brown to black, mostly black; antennæ, mouthparts (except mandibles), femora, and tarsi light amber; tibiæ, posterior lateral area of prothorax, and tumid area on the anterior lateral portion of elytra dark amber.

Emerging.—As soon as the adult becomes mature it slowly bites its way to the surface and, selecting a warm day, emerges from the section of wood. The emergence hole can be distinguished by its sharp, square edge and by the fact that usually it is in the open and not hidden in a crevice or similar place. If the weather conditions are not suitable, the beetle will often turn around and go back into the emergence hole for a time before it finally leaves the section.

Flying.—Both sexes are strong fliers and are on the wing a good deal if the weather is warm.

Feeding.—After emergence the males appear to get under a bark scale or similar place and feed while they wait for the females to start their entrance galleries into the new wood. The females do not appear to feed until they have the entrance gallery well started and are into the wood. None were observed to feed on the bark. The male often comes to the gallery and feeds on the borings thrown out by the female.

Boring.—Apparently most of the boring is done by the female. The male may make a short food gallery or impression, but the egg gallery is made by the female. Soon after emergence she seeks a suitable place in which to deposit her eggs. Finding such a place at a knot, scar, bark scale, or crevice in or under the bark or in the wood.

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[11] For a detailed description of the mature beetle, see Appendix, p. 54.

between two sections of wood, or where a section of wood rests against something else, in fact any place where the proper leverage can be obtained, she starts boring.

Gnawing, and circling as she gnaws, she soon has in the bark or wood a circular impression with a smooth rounding edge and slightly larger than herself. During this time her claws grasp the bark or wood and her abdomen is parallel with the surface. As soon as the hole is deep enough she gets the prothorax with its rasplike rugosites against one side and with the front pair of legs grasps the other side. The legs of the middle pair brace and push with the tibial spurs, while those of the rear pair extend backward close to the abdomen, which gradually becomes elevated as the boring progresses. Continually gnawing and revolving back and forth, sometimes making a complete circle, she eventually buries herself in the wood perpendicular to the surface. This takes about 24 hours.

Apparently the boring goes on continuously, faster during the warmer part of the day and slower during the cooler night time. The borings are kicked out by the legs. As the gallery deepens the insect has to back up, kicking out the borings as she comes. The male often assists the female by pushing against her declivity with his mandibles, thus adding weight and stability to the hold. He also assists in throwing out borings when the gallery gets deeper.

When the gallery has reached a depth of about 8 millimeters, which is slightly more than the length of the female, it turns rather abruptly, curves backward toward the surface, and then runs parallel to it across the grain of the wood. (Pl. III, Fig. 1.) The length varies from a few millimeters to 125 millimeters, or about 5 inches. The average length is about 63 millimeters, or $2\frac{1}{2}$ inches.

Mating.—Mating usually takes place about the time the female has bored her length into the wood. Sometimes in the laboratory pairs were found mating on windows, etc., but most of the observations indicate that this is abnormal. Usually the mating is started by the male clawing at the declivity of the female with his front feet. Sometimes, however, he backs up to her and uses his back feet. Upon being clawed, the female protrudes her anal segments with the sexual organ, whereupon the male places the tip of his abdomen to hers and they mate. (Pl. III, Fig. 3.) Copulation lasts from 10 to 70 seconds. Our records show that one copulation is sufficient. One female laid at least 140 fertile eggs after being separated from the male. (See diagram, Fig. 13.)

Egg laying.—As the egg laying occurs in the wood it was not observed, but the observations made on the egg galleries and the eggs shortly after they were laid indicate how it was done. Any time after the female has reached the solid wood she places the ovipositor

in a suitable pore at the side of the gallery and deposits an egg from 1 to 2½ millimeters into the pore from the gallery. (Fig. 14.) Only a single egg is deposited in each pore. Apparently the pores are selected with considerable care, for oftentimes the gallery runs for

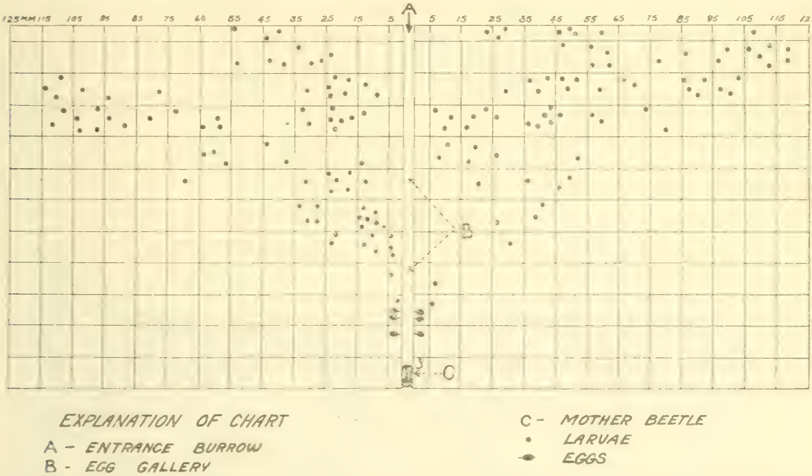

FIG. 13.—Diagram of section of oak wood with which one pair of adults of the California lead-cable borer were placed, showing resulting infestation. May 19, 1920, 5 p. m. Pair of adults placed with section of oak. May 20, 1920, 10 a. m. Female started entrance gallery. Male assists. May 20, 1920, 4.30 p. m. Male taken short distance away several times. Always returned. Pair mate. May 21, 1920, 12 m. Female about twice its length in wood. Male removed. May 22 to June 21, 1920. Female still boring. Section of wood cut up and examined thoroughly. Female at terminus of gallery, weak. Gallery 115 millimeters long. Larvæ and eggs found as indicated. (Distances in millimeters.)

some distance between places where eggs are laid. The indications also are that in going back and forth to throw out the borings from the entrance the female may stop at any point along the way and lay an egg in the nearest suitable pore: at least the variation in

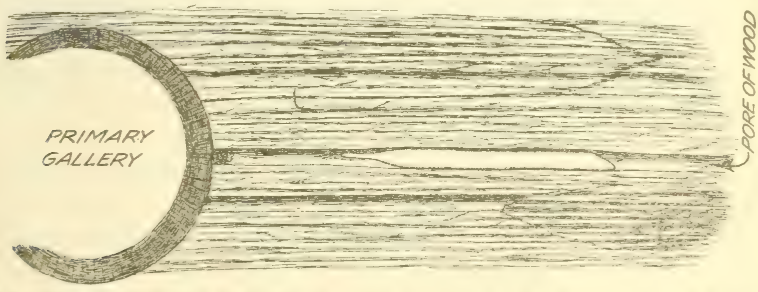

FIG. 14.—Egg of California lead-cable borer in pore of wood. Enlarged about 21 times.

the sizes of the larvæ and the length of their mines indicate this. (See diagram, Fig. 13.) She must also back down and lay, because eggs are found so close to the terminus of the gallery that any other method of oviposition seems impossible.

Healthy wood cut, felled, or broken by the wind and down from two weeks to six months seems to be preferred by the beetle when she excavates the egg gallery. If there is none of this accessible, she will enter logs or stumps from which she has emerged or attack other dead or dying material. She does not like to enter wood killed by fungi or other slow-killing timber diseases.

Length of life.—The females live longer than the males. In the cages with sections of wood the males lived from 10 to 18 days and the females from 30 to 44 days. In the cages, on the cables where there was no wood, both sexes died in from 5 to 7 days.

CONTROL EXPERIMENTS.[12]

TESTS AT FALLS CHURCH, VA., 1918 AND 1919.

In 1918 a large quantity of California oak (*Quercus agrifolia*) (500 pounds) infested with *Scobicia declivis* was shipped by Mr. Burke from Los Gatos, Calif., to the forest insect field station of the Bureau of Entomology at Falls Church, Va. This was placed in a large, specially constructed cage. In June adults began to emerge and some were caged in glass cylinders with covers of test-sheet lead. In some cases the smooth lead was marked—criss-crossed with a nail so that the beetles would not slip; in other jars small strips of copper were nailed to the lead so that an arch was formed to enable the beetles to get a footing on the smooth lead and brace themselves to bore. Adults so caged, when they lost their footing, often spun around the smooth lead on their heads (partly flying) in attempting to regain a foothold. They did not bore through the test lead sheathing under these conditions, and all the efforts to assist the beetles failed.

Other adults were left to fly freely in the large cage to attack the suspended cables of different alloys hung on various types of rings, wire and tape. (Fig. 15.) Several pairs of these adults infested the corks from 100-millimeter vials, constructing their galleries in the corks.[13] The beetles entered the heavy beams (Southern yellow pine) supporting the cage and the old California laurel limbs. They did not attack the suspended cables.

Sheet lead of different alloy composition was tightly wrapped around infested sections of logs, the sides being overlapped and nailed into close contact with the wood. (Pl. VII, Fig. 1.) The ends also were covered. Many adult beetles bored through double thickness of No. 3 alloy lead (99 per cent lead, 1 per cent antimony); No. 2 (95 per cent lead, 4.5 per cent antimony, 0.5 per cent tin), and

[12] These control experiments were made in active cooperation with the American Telephone & Telegraph Co. and associated companies, who supplied the metals, alloys, etc., and installed the test cables in Virginia and California.

[13] There are records of the adults entering a loaf of bread in California and a Douglas fir window sill in Oregon.

No. 1 (commercially pure lead) were also penetrated. The lead sheathing is over one-sixteenth inch in thickness.

RESULTS OF EXPERIMENTS AT FALLS CHURCH, VA., 1918 AND 1919.

It is believed that the results obtained at Falls Church, Va., *were not conclusive* and that climatic conditions may be an important factor influencing attack by the beetles. The No. 4 lead, with a higher per cent of tin in the alloy (97 per cent lead + 3 per cent tin), was not attacked. The sheets of lead No. 5 (commercially pure), with emery embedded, were not large enough to wrap about the logs. Antimony is apparently of no value in resisting the attack of the beetles.

It was decided that this test should be continued in California and that no further infested wood should be shipped to the East. Of

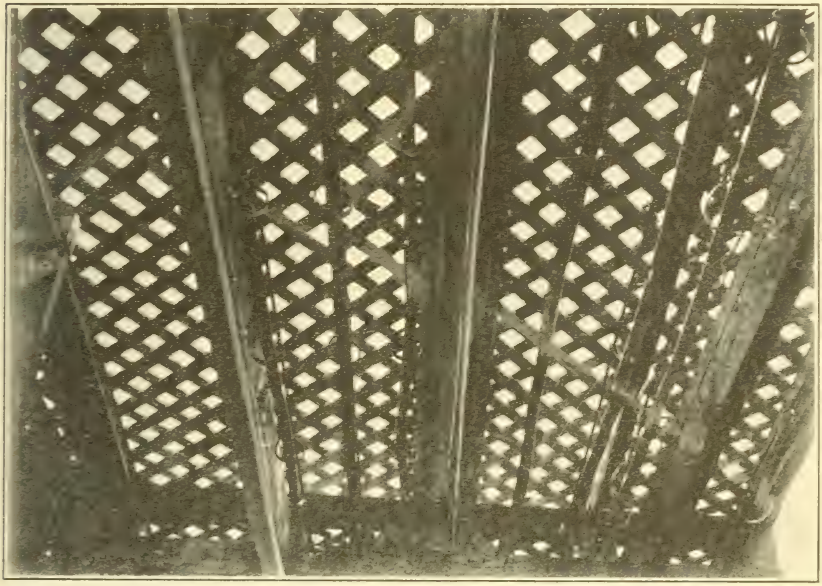

FIG. 15.—Interior of experimental cage at Falls Church, Va., showing lead-sheathed cables of different alloy composition suspended on different types of rings from beams of roof.

course, this is not an absolutely fair test, since it is well known that emerging insects will, if necessary, penetrate materials which they would not ordinarily attack.

Lead embedded with emery has a disadvantage in that it will rust, will "run," and would discolor whatever it fell on beneath the aerial cable.

TESTS AT LOS GATOS, CALIF., 1918–1920.

EMERGENCE EXPERIMENTS.

To determine just what the beetle is able to do and, if possible, to find a repellent or nonpenetrable substance for a cable sheath, a

number of sections of infested wood were treated with various repellents and poisons and covered with various alloys, metals, and other promising materials in such a manner that these would have to be penetrated before emergence could take place. Usually the sections were dipped in the liquids, painted with the heavier fluids, and rolled up into or covered with the metals. In all cases parts of the sections were left untreated or uncovered to serve as checks.

The following materials were used during the various tests from year to year (1918 to 1920): Beef tallow; a commercial brand of refined paraffin; a mixture of the tallow and the refined paraffin; arsenate of lead; a water solution of sodium silicate similar to "water glass"; creosote; No. 38 varnish; spar varnish; tire tape (the common friction tape used by electrical workers); tarred building paper; commercially pure lead sheathing (referred to as "No. 1 lead"); lead-antimony-tin sheathing, or "No. 2 lead" (95 per cent lead, 4.5 per cent antimony, 0.5 per cent tin); lead-antimony, containing 94 per cent lead and 6 per cent antimony) ("No. 2a lead"); lead-antimony, containing 99 per cent lead and 1 per cent antimony ("No. 3 lead"); lead-tin, containing 97 per cent lead and 3 per cent tin ("No. 4 lead"); commercially pure lead embedded with emery filings; lead carborundum coated; lead copper coated; lead tin coated; zinc 0.01 inch thick; and sheet steel 0.006 inch thick.

After being treated the sections were placed in the open laboratory under conditions of normal temperature and moisture. All of the infesting insects seemed to have transformed naturally and carried on their regular functions in a normal manner.

Attacking Experiments.

As it was realized that the insect probably would put forth every effort to emerge and that to do this it might go through repellents and other substances which it would not otherwise attack, a number of uninfested sections of oak and other woods in the proper condition for attack were treated and exposed to attack. The following materials were used to treat these sections: Arsenate of lead paste, black paint, P. & B. paint (a protective paint used by the telephone company workers), pine tar, black iron enamel, white porcelain enamel, creosote, carbolineum (a high grade of coal-tar creosote), nicotine sulphate containing 40 per cent of nicotine, a solution of sodium silicate, a refined paraffin, two grades of a commercial chlorinated naphthalene compound, beef tallow, and varnish.

In order to get a good check on the action of the substances used, untreated sections of wood were kept under the same conditions as the treated sections. Some of the sections were left exposed in the open laboratory where numerous beetles were flying every day during

the season, and others were confined in lamp-chimney cages with freshly emerged beetles.

Cable Experiments.

Besides the experiments with the insects and the wood, a number of experiments were conducted with the insects and the regular telephone cables (Pl. X, Figs. 1–4) to see if any facts could be discovered that would throw light on the reason for the attacks and the methods of preventing them.

Caged cable.—Two large screened cages were built out of doors and a number of cables were suspended in these in as normal a manner as possible. Different types of suspension rings were used and some cables were charged with a 60-cycle lighting current of electricity, while others were left uncharged. Numerous freshly-emerged beetles were placed in the cages, some unconfined and some confined in smaller cages built around a short length of cable and one or two suspension rings. (Pl. X, Figs. 2 and 4.) Some sections of the cable were treated with substances to make it more or less attractive or to trap the insects. These substances were oak-bark tea, tallow, refined paraffin, P. & B. paint, and pine tar.

Service cable.—To be sure that the actual conditions met with in the commercial cables were present in the experiments, several small cages were placed around the service cables of the Los Gatos Telephone Co. (Pl. X, Fig. 1.) These were kept supplied with beetles and the results noted. Some of the cages inclosed suspension rings and others were attached between the rings close enough to the lead to allow the beetles leverage for boring at any point along the cable.

Several tests were made on the commercial cables to see if any magnetic fields existed about them, but no evidence was found that any existed. Several times beetles were placed in a magnetic field created by an ordinary magnet, but so far as could be determined this had no effect on them.

RESULTS OF EXPERIMENTS AT LOS GATOS, CALIF., 1918–1920.

Emergence Experiments.

As the emergence experiments were numerous, the results can best be given in a series of tables (Tables 1–4) and photographs (Pls. IV–IX). None of the metals, repellents, or poisons used appeared effective against normal emergence except the zinc (Table 2), (Pl. VI, Fig. 4), steel (Table 2) (Pl. IV, Figs. 1–3), and possibly friction tape (Table 2). The beef tallow when softened by the sun stopped the emergence (Table 4) (Pl. IX, Fig. 1). As at Falls Church, Va., beetles entered 30-millimeter corks used as stoppers to vials containing alcohol. (Pl. IX, Fig. 4.)

TABLE 1.—*Emergence of beetles of the lead-cable borer through metals and other material applied in layers to infested sections of wood; Los Gatos, Calif., 1918–1920.*

Experiment No.	Number of layers used.	Order in which leads and other metals were applied, starting next to the wood (numbers refer to kinds of lead, p. 22).	Number of beetles emerging from wood under metal.	Number of beetles escaping between metal and wood.	Number of beetles stopped by first layer of metal.	Other adults penetrated the various layers as follows. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Remarks.
55c	8	Carborundum[1] up	9	1	0	8	8	5	1	1	1	0	0	Only one beetle penetrated more than 3 layers. It penetrated 6.
21a	8	Emery-lead down, 4, 3, 2, 1, 2a, sheet steel, zinc.	16	1	8	7	7	4	2	1	1	([2])	([3])	Last one was stopped by sheet steel.
25a	7	3, 2, 2a, steel, 1, zinc, 2a	30	13	7	10	10	10	([2])	5	[3] 5	5	....	Smaller strips of steel and zinc were used. The last 5 beetles mined on either side of these. Five were stopped by steel.
25b[4]	6	2, 4, zinc, 1, steel, 2a	30	14	4	12	10	[3] 1	0	0	0	....	....	In this case no beetles mined to the side of the zinc or the steel as in No. 25a.
25c	6	4, 3, steel, 2a, zinc, 1	22	8	1	13	11	([2])	0	0	0	....	....	In this case no beetles mined to the side of the zinc or the steel as in No. 25a.
26a	6	Carborundum up, copper up, 2a, 2, steel, 1.	84	29	14	41	37	35	29	([2])	20	....	....	9 were stopped by strip of steel; 20 mined to the side and escaped.
26b[5]	6	Carborundum down, copper down, 2a, 2, steel, zinc, 1.	64	1	13	50	42	37	31	([3])	11	....	....	20 were stopped by zinc; 11 mined to the side and escaped.
26c	6	Copper up, carborundum up, 2a, 2, steel, 1.	22	13	0	9	7	7	6	([2])	2	....	....	4 were stopped by steel; 2 mined to the side and escaped.
26d	6	Copper down, carborundum down, 2a, 2, zinc, 1.	13	4	2	7	7	5	4	([3])	4	....	....	No adults mined under strip of zinc.
27	6	2 sheets carborundum together, 3, 4, 1, 2a.	35	15	0	20	17	14	13	10	9	....	....	3 stopped in the second layer of carborundum down.
28	6	2 sheets copper together, 3, 4, 1, 2a.	35	18	5	12	10	10	7	6	4	....	....	2 stopped in the second layer of copper down.
2A[6]	4	2, 3, emery down, 4	23	5	6	12	12	3	2	....	....	....	....	9 were stopped by emery down.
2B[6]	4	3, 4, 2, emery up	18	11	0	7	7	7	5	....	....	....	....	2 stopped by the last layer before they reached emery.
1W	4	Emery up, 3, 4, 2	18	3	11	4	4	4	4	....	....	....	....	4 that penetrated the first layer also went through the last.
26E	7	Layers of building paper	21	0	0	21	20	16	8	4	4	4	....	

[1] "Up" means that the lead was between the infested wood and the carborundum; the word "down," used elsewhere, denotes that the material described is next to the infested wood.
[2] Steel.
[3] Zinc.
[4] See Pl. V, Fig. 3.
[5] See Pl. V, Figs. 1 and 2.
[6] See Pl. V, Fig. 4.

NOTE.—Besides these a large number of single-layer experiments were conducted. As the same lead was used in the above it would be useless to tabulate them. No differences could be detected in the ability of the sexes to penetrate the various alloys and other substances used in the experiments.

TABLE 2.—*Emergence of beetles of the lead-cable borer through metals and other materials wrapped around infested sections of wood; Los Gatos, Calif., 1918–1920.*

Experiment No.	Kind of metal used.	Number of layers or thicknesses used.	Total number of beetles emerged from the wood.	Number of beetles escaping between wood and metal.	Number of beetles stopped by first layer.	Other adults penetrated the various thicknesses, as follows:												Remarks.
						First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Fourteenth.	Nineteenth.	Twenty-fourth.	
55*b*	No. 1 lead	10 to 11	45	4	21	20	14	11	10	9	9	3						No adult penetrated all of the layers.
19	No. 2a lead	4 to 5	29	3	6	20	17	14	12	2								Eight emerged and escaped through the fourth, leaving two in fifth.
20*a*	Do	4 to 5	18	0	4	14	13	9	8	4								Three emerged and escaped through the fourth, leaving one in fifth.
55*a* [1]	Do	26 to 27	48	4	7	37	34	32	28	27	26	24	21	18	13	8	2	This was greatest penetration, about 1 inch.
4 [2]	No. 3 lead	1 to 2	27	5	13	9	3											Six emerged through first and escaped. Layers unevenly rolled.
3	No. 4 lead	2 to 3	38	3	12	23	14	2										Twelve emerged through second and escaped.
51	Tinned down	6 to 7	10	4	1	5	3	3	3	2	1							Last two emerged at fifth and sixth and escaped.
52 [3]	Do	2 to 4	58	3	31	24	20	2	2									Eighteen emerged through second and escaped.
60	Do	6 to 9	15	2	10	3	3	3	2	1	1	1						Three strips were rolled together.
54*c* [4]	Do	3 to 4	14	1	7	6	4	4	2									Two emerged through third and escaped.
33*a*	Copper down	1 to 3	11	2	7	2	2	2										
54*b* [4]	Do	3 to 4	17	1	4	12	7	4	1									
33*b*	Copper up	2 to 3	19	6	9	1	3	3										
29*b*	Carborundum down	2 to 3	26	0	10	16	8	3										Four emerged through second and escaped, one stuck in three.
54 [4]	Do	3 to 4	17	0	3	14	6	1										One emerged through third and escaped, leaving none for fourth.
29*a*	Carborundum up	2 to 3	5	4	0	1	1	1										The one that started went through all three.
22*a*	No. 2a lead, steel	3	11	3	0	8		[5] 8										No. 2a lead was rolled down or next to section.
22	Do	2 to 3	10	2	0	8	4	[5] 4										Same as No. 22a except that No. 2a lead is wider.
45–49 [6]	Zinc	2 to 3	228	0	225	3	[7] 76											No adults emerged through zinc.
39–44	Steel	2 to 3	176	0	[8] 176													
66*a*	Friction tape	1 to 2	10	0	3	7	[9] 1											
66*b*	Do	1	3	0	1	[10] 2												

[1] See Pl. VII, Fig. 1, and Pl. IX, Fig. 3.
[2] See Pl. VI, Fig. 1.
[3] See Pl. VI, Fig. 2.
[4] See Pl. VIII, Fig. 3.
[5] Stopped by steel.
[6] See Pl. VI, Fig. 4.
[7] Made impressions on zinc.
[8] None made any impression on steel.
[9] None emerged.
[10] Both emerged through one layer.

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TABLE 3.—*Emergence of beetles of the lead-cable borer through metals partially treated with repellents and poisons and wrapped around infested sections of wood; Los Gatos, Calif., 1918–1920.*

Experiment No.	Repellent used.	Where applied.	Kind of area.	Total number of beetles emerged from wood.	Number of beetles escaping between wood and metal.	Number of beetles stopped by first layer.	Other beetles penetrated the various layers, as follows: First.	Second.	Third.	Fourth.	Fifth.
64	Three coats spar varnish on No. 3 lead	Half of underside, then rolled three to four times.	Untreated area	12	0	8	4	1	1	1	......
			Treated area	16	3	7	6	3	2	2	......
50	Three coats spar on section and three coats spar on No. 3 lead.	Half of underside, then rolled four to five times.	Untreated area	1	0	1	0	0	0	0	0
			Treated area	7	2	3	2	2	1	1	1
56 [1]	Three coats spar on section and five coats spar on No. 3 lead.	....do	Untreated area	9	2	2	5	3	3	3	3
			Treated area	10	1	2	7	7	6	4	3
18	One coat of spar on section and one coat of spar on No. 3 lead.	Half of underside, then rolled three to four times.	Untreated area	2	1	0	1	0	0	0	......
			Treated area	3	1	2	3	2	1	1	......
16	1 coat spar on No. 2 lead	Half of underside, then rolled two to three times.	Untreated area	9	4	3	2	1	1	......	......
			Treated area	23	4	9	10	6	4	......	......
15	Do	....do	Untreated area	8	3	3	2	2	1	......	......
			Treated area	14	7	6	1	1	1	......	......
62 [2]	Three coats spar on section and three coats spar on No. 4 lead.	Half of underside, then rolled four to five times.	Untreated area	2	3	3	2	1	1	1	
			Treated area	4	4	5	4	3	1	1	0
12	One coat No. 38 varnish on No. 4 lead	Half of underside, then rolled two to three times.	Untreated area	3	1	2	0	0	0	......	......
			Treated area	12	3	5	4	2	0	......	......
11 [3]	Medium coat beef tallow on No. 4 lead	....do	Untreated area	23	8	0	15	8	6	......	......
			Treated area	37	0	12	25	13	8	......	......
9	Heavy coat of paraffin on No. 3 lead	Covered all of underside, then rolled two to three times.	All treated	32	6	15	11	5	3	......	......
59	Four coats spar on section	Rolled carborundum lead down, four to six times.	....do	13	0	7	6	3	2	1	0
61	Three coats No. 38 varnish on section	Rolled copper lead down, four to six times.	....do	15	0	8	7	2	1	1	0
10	Heavy coat arsenate of lead on section	Portion of section rolled with three layers of No. 4 lead.	Poisoned and rolled with lead.	7	2	5	4	3	2	......	......

[1] See Pl. VIII, Fig. 2.
[2] See Pl. VII, Fig. 2.
[3] See Pl. IX, Fig. 2.

TABLE 4.—*Emergence of beetles of the lead-cable borer from infested sections of wood through poisons, repellents, and varnishes; Los Gatos, Calif., 1918–1920.*

Experiment No.	Repellent used.	Where applied.	Number of adults emerged in treated area.	Number of adults emerged in untreated area.	Total number of adults emerged from infested section.
1	5 coats No. 38 varnish	All of infested section	63	....	63
2	4 coats No. 38 varnish	Four-fifths of infested section	78	13	91
3	3 coats No. 38 varnish	Two-thirds of infested section	48	31	79
4	5 coats spar varnish	All of infested section	102	....	102
[1] 5	.....do	Two-thirds of infested section	46	11	57
6	4 coats spar varnish	Four-fifths of infested section	54	20	74
7	3 coats spar varnish	Three-fourths of infested section.	73	18	91
[2] 8	1 heavy coat beef tallow	.....do	26	8	34
9	1 heavy coat of refined paraffin	.....do	53	18	71
10	3 coats of water solution of sodium silicate.	.....do	93	35	128
11	Heavy coat of lead arsenate	One-half of infested section	33	30	63
[1] 12	1 coat white enamel paint	Three-fourths of infested section.	37	18	55

[1] See Pl. VIII, Fig. 1. [2] See Pl. IX, Fig. 1.

NOTE.—So far as could be determined, none of these materials hindered the emergence of the beetles to any extent. The beef tallow when allowed to soften in the sun suffocated the beetles and prevented their emergence.

ATTACKING EXPERIMENTS.

Arsenate of lead.—Sections of oak and elm were covered thoroughly with full-strength arsenate of lead paste and placed in individual lantern globes with beetles. Nineteen out of twenty-five entered the sections and showed no effect from the poison. Normal galleries were excavated and eggs laid which hatched into healthy larvæ.

Black paint and one-third creosote.—Four out of six beetles entered at once.

P. & B. paint.—Numerous entrances made. Beetles were able to walk on surface of paint soon after it was applied.

Pine tar.—Thoroughly attacked. The surface remained "sticky" for a short time, especially in warm weather.

Black iron enamel.—Used both straight and mixed with one-third creosote. The beetles attacked and penetrated without trouble.

White porcelain enamel.—Nine out of twelve beetles soon entered.

Creosote.—When sections were treated with pure creosote and placed in the lantern-chimney cages the fumes killed the beetles. When these same sections were taken from the chimneys and placed in the open laboratory the beetles attacked them and entered the wood.

Carbolineum.—The beetles react to carbolineum about the same as to creosote. Some died in a few days after being placed in the chimneys with freshly dipped sections but a few bored into the sections through the carbolineum coat.

Nicotine sulphate.—The fumes of this tobacco product acted as did the creosote. Beetles placed in chimney cages with sections of wood treated with it soon died. This effect soon wore off, however, and beetles entered the wood through the insecticide after the sections of wood remained in the open air for a time. When one-third nicotine sulphate was added to black iron enamel and white porcelain enamel the fumes were strong and kept the beetles from entering while the sections were in the small cages. As soon as they had aired for a time the beetles entered.

Water solution of sodium silicate.—In 1919 a number of sections were treated with this preparation. In only 1 case out of 45 did a beetle enter a treated section, and in this case it appeared to be because of a faulty application. When the material was tested with water, however, it appeared soluble, and therefore its use for cable protection would be impracticable.

Refined paraffin.—This had no repellent effect upon the beetles while it was cold and hard. Some bored into a cake of it. When the weather was warm it softened enough to kill them when they bored into the wood through it.

Chlorinated naphthalene compounds.—These were received too late for a thorough test. Several sections of wood were treated and placed in the chimney cages and beetles introduced. The insects entered through the thinly coated sections without trouble, but died without entering the thicker coated ones. This may have been due to the fact that it was the last of the season and they were weak.

Beef tallow.—Numerous sections treated with this were placed in the cages with beetles. During the early part of the season when the weather was warm and the tallow soft the beetles were killed as they attacked. Sections, even after the tallow had melted off, were immune as long as the weather was warm. (Pl. IX, Fig. 2.) Sections treated later in the season, when the heat did not soften the tallow after it was applied, were attacked by the beetles, which entered the wood and laid their eggs. (Pl. IX, Fig. 1.)

Beef tallow-refined paraffin.—Sections treated with a mixture of two-thirds tallow and one-third refined paraffin kept out the beetles as long as the mixture was soft enough to kill them.

Varnish.—Three and four coats of spar varnish were applied to a number of recently cut sections of oak. The beetles entered these and laid their eggs.

CABLE EXPERIMENTS.

Caged cable.—Several thousand beetles were placed in cages containing cables suspended in the usual manner by rings from messenger strand. Some of these cables carried the usual current of electricity,

while others did not. In none of the cases observed were any beetles found that had made an attempt to enter the cable. As a matter of fact, they paid no attention whatever to it. Painting it with fresh and old oak-bark tea and other substances seemed to have no effect on them as long as they had the large cages in which to fly. They walked on the P. & B. paint and the pine tar soon after they were applied without getting stuck.

Numerous beetles were then placed in small cages which confined them closely to the cables. These also failed to attack except in one case where the cable had been painted with a tea made from fresh oak bark and kept in a tight jar for some time. Eighteen beetles were placed in this cage and fifteen attempts to penetrate the cable were found. Five of these were one-fourth to one-half penetration and the others less than that.

During this same time numerous beetles entered an oak stick that was placed in the large cage, which indicated that they were in the proper stage of maturity to make the experiment practical.

Service cables.—Five hundred and sixteen beetles were placed in five small cages on the service cables in Los Gatos. One of these cages inclosed rings and marline ties and the screen was not close enough to the cable for the beetles to attack anywhere but at the rings; the other cages were between the rings, and the screen was close enough to the cable so that the beetles could attack from any point. One of these cages was painted with black paint to see if this would give a better foothold, but it proved a failure. One hundred and twenty-nine beetles were placed in the first cage, which allowed for the regular attack to be made at the suspension rings or marline tie. None made any attempt on the cable. Three hundred and seventy-six beetles were placed in the other three cages, where an attack could be made at any point. In all three of these, attacks on the cable were made, 5 in one, 11 in one, and 7 in the third, or a total of 23 attacks. Of these only 1 went completely through the sheath, 6 bored from one-third to one-half through, and the others made only slight impressions in the lead.

NOTE.—To get an idea of the ease of applying various substances to the cables, the following cooling tests were made. In each case the material was heated to a liquid state and then left standing until it hardened again.

Beef tallow	Hardened in 1 hour, 10 minutes.
Refined paraffin	Hardened in 20 minutes.
A chlorinated naphthalene compound, No. 1001	Hardened in 10 minutes.
A chlorinated naphthalene compound, No. 1008	Hardened in 7 minutes.

This indicates that the tallow would be much more easily applied than any of the other compounds that would soften under the heat of the sun.

EXPERIMENTS IN CALIFORNIA DURING THE SEASON OF 1921.

The results obtained from the experiments of 1918 to 1920 suggested the most promising ones for the season of 1921. Two lines of investigation are involved: (1) To determine why the insect attacks the cable, and (2) how to prevent the attack.

The bark of the wood normally attacked by the beetles is dark. To see if color has any influence on the attack, paints of various colors were applied to sections of wood and sections of cable.

As beetles appear to be attracted to ferments in the case of the oak tea, wine casks, and vials of alcoholic specimens, several of these liquids were applied to sections of wood and sections of cable to determine their influence. In the experiments of 1920 the beetles were not attracted to the cables in cages when alternating current of commercial frequency was applied to the conductors, but they did attack the commercial cables in town (Los Gatos) in parallel tests made that year. During 1921 the cooperating telephone company supplied apparatus whereby alternating current of talking frequencies could be applied to the cable conductors with a view to determining whether the higher frequencies of the talking current had any influence in producing the attack on the service cables.

As the results obtained by the use of repellents, poisons, alloys, etc., indicate that the repellents and poisons are useless and that the alloys are very little, if any, better than the regular commercial lead sheathing, the only hope for protection appears to lie in mechanical protection which can be obtained from greases, asphalt and fabric, rubber and fabric, and zinc or steel sleeves at the rings. Beef tallow seems to be the most promising grease and it was given a thorough test; tire tape impedes the mining of the beetle considerably, so several combinations of asphalt and fabric and rubber and fabric were tried; thin steel can not be penetrated, so sleeves of this material were placed around the cable where the rings support it. To make a good practical test of all of these materials a section of cable was selected in an area where past damage had been severe and one ring was treated with tallow, one with fabric, one with a steel sleeve, one left as usual for a check, and so on for several spans.

As will be seen, these experiments gave definite results but it must be remembered that, because of the periodic and variable nature of the attack (i. e., in different localities at different times) the chance for securing, in service tests during one season, any immediate proof of the effectiveness of these protective measures was not very great, and the service tests will need to be followed up for a period of several years.

RESULTS OF EXPERIMENTS IN CALIFORNIA IN 1921.

During 1921 the following experiments with the lead-cable borer were carried on at the Los Gatos Forest Insect Laboratory in the

town of Los Gatos, at Palo Alto, and at Santa Barbara. The work was carried on in cooperation with the American Telephone & Telegraph Co., the Pacific Telephone & Telegraph Co., the Santa Barbara Telephone Co., and the Los Gatos Telephone Co. A total of 6,953 beetles were reared and used in the various experiments. One of the most interesting results obtained was the determination that the beetles are unable to penetrate *pure gum rubber*. Another is the catching of the beetles by placing sticky tree-banding material on the cables.

Cage Experiments.

To determine if possible the attractive effect of varying currents of electricity on the beetles the following experiments were conducted.[14]

Experimental cage.—One of the large cages used in 1920, which contained seven cables 10 feet long suspended from the messenger strands by rings of various types, was again used. An engineer of the Pacific Telephone & Telegraph Co. designed an apparatus which made it possible to use the alternating currents of higher talking frequencies as well as the currents of lower commercial frequencies used in 1920. The idea was to create in these test cables any condition that could occur in the regular commercial cables.

Of the seven cables in the cage, four were connected with the apparatus and three were left "dead." Cable No. 1 had four pairs in parallel tapped to a 1,000-cycle circuit and the far ends shorted; cable No. 2 had four pairs in parallel tapped to a 1,000-cycle circuit and the far ends open; cable No. 3 had four pairs in parallel tapped to a 1,000-cycle circuit and the far ends shorted and connected to the sheath; cable No. 4 had the sheath connected to the 1,000-cycle circuit. Two drops were used, No. 1 for cables 1, 3, and 4, and No. 2 for cable 2. Both drops could be used singly or together and a battery could be switched in or out.

Some beetles were liberated in the main cage and were free to attack any of the cables, charged or dead, while others were confined in smaller cages to the various cables. During the season of five months, April 22 to September 27, 2,714 beetles were liberated in the cage on 24 different occasions of varying climatic conditions. A few slight borings were noted on cables 2 and 3, but as a whole the experiment was without any definite positive result.

Aerial cage.—Two small wire-screen cages were placed around a regular 25-pair commercial cable in Palo Alto. These cages were placed on the cable where it ran through the top of a large acacia tree, which caused varying conditions of light and shade. Each cage inclosed several suspension rings as well as a section of the cable.

[14] All of the officials of the Pacific Telephone & Telegraph Co., the Santa Barbara Telephone Co., and the Los Gatos Telephone Co. cooperated to the fullest extent in the experiments.

On seven different occasions from July 8 to August 8, 268 beetles were placed in each cage. The beetles crawled all over the cable and rings and mated and otherwise acted normally. In a similar cage suspended in the tree and inclosing several sections of oak wood they entered the wood and laid their eggs. In the cable cages, however, they made only a few minor attempts to bore the cable. On one occasion a quantity of alcohol was poured on a section of the cable in an attempt to stimulate them to action, but without effect.

Office cage.—Two screen cages were placed around two different 600-pair commercial cables in the basement of the Palo Alto telephone office. These cables lead directly to the switchboard. On six different occasions from June 30 to September 21, 260 beetles were placed in each of these cages. Only a few minor attempts to bore the cables were made by the beetles.

Battery cage and alcohol cage.—The wire chief of the Palo Alto office of the Pacific Telephone & Telegraph Co. suggested that there might be some slight galvanic action between the galvanized suspension rings and the lead sheath. In order to determine the attractive effect of a slight current on the beetles and also whether they could detect alcohol through the lead sheathing, a small wire-screen cage was made and suspended from the ceiling of the basement by strings.

Two sections of lead cable sheathing about 12 inches long were emptied of the inclosed wires. One was filled with grain alcohol and sealed at both ends, and the other was left empty and sealed at both ends. Both were suspended by strings in the cage. The alcohol-filled cable was suspended just far enough above the bottom of the cage to allow the beetles crawling on the cage to reach it. The empty cable was suspended in a similar manner. One end was attached to a battery which had the other pole attached to the screen of the cage. The idea was that the beetle crawling on the bottom of the cage would complete the circuit as soon as it touched the cable.

During the period from July 22 to August 8, 110 beetles were placed in the cage on three occasions. The cables were removed on August 12 and carefully examined. Each showed a few slight scratches but no definite boring. A strip of heavy paper was placed on the bottom of the cage to give the beetles a smooth foundation from which to bore. Thirty beetles were placed in the cage, and on August 22, 15 more. August 29 the cables were removed and again examined. The alcohol cable was bored twice at one of the sealed ends. One beetle had penetrated to the alcohol and was drowned in its hole. The battery cable had one hole toward the middle, where a beetle or beetles had entered and two holes at one end where beetles had gone out.

The holes were plugged with wax and the cables replaced in the cage with 50 beetles. On September 7, 12 fresh beetles were placed

in the cage. The cables were examined on September 13. No new work was found in the battery cable, but considerable new work was noticed in the alcohol one. Numerous attacks had been made on the underside, two of which had penetrated the lead and were allowing the alcohol to escape. These were filled with wax and the cables returned to the cage. The cage was examined on September 21. There was no new work, but the alcohol had escaped. Thirty-three beetles were placed in the cage and the battery connections removed. On October 6 the cage was examined and most of the beetles were found to be missing. Two more holes were found in the alcohol cable and numerous small borings. Both cables were cut into twos and nine beetles were found inside of the battery cage which had the battery detached September 21. Some were trying to bore out at the ends.

Taking the experiment as a whole, the results are indefinite. One beetle bored a hole into the battery-attached cable and at least six penetrated the alcohol-filled one. During the time the cage was in use, however, 250 beetles were placed in it and practically all of the boring was done by a few beetles from two or three lots. If any particularly attractive condition had been created it seems as though more boring should have been done. The experiment opens up a new field, however, and should be continued this year (1922).

Holes.—To determine if the beetles are attracted to holes already started in the cable by other means, a section of a cable was punctured and partially punctured by a number of holes, some shallow and some nearly through the sheath, and placed in a cage. Forty-five beetles were introduced into the cage on two different occasions. Six males were found in the holes at various times but no females.

Colors.—To determine the attractive effect of colors on the beetles, sections of dead cable and sections of wood were painted in alternating rings of red, yellow, and green and placed in the large experimental cage. Over 1,500 beetles had a chance to attack these, but none did.

Fermentation Experiments.

Alcohol.—To determine the attractive effect of alcohol on the beetles the following experiments were carried on in addition to those mentioned under "Aerial cage" and "Battery cage." Twenty glass vials 11 millimeters by 60 millimeters were placed in a cage. Ten of these were empty and 10 contained grain alcohol. All were closed with cork stoppers. They were placed in the cage in two rows, empty alternating with alcohol-filled, and cork end alternating with glass bottom. Forty-five beetles were placed in the cage on two different occasions. One cork of an alcohol-filled vial was attacked and bored several times and two others slightly bored.

All of these attacks were at the point of contact of the glass with the cork. One cork of an empty vial showed a slight attack well above the glass.

In another experiment two 30 by 100 millimeter vial corks were soaked in alcohol for three days and then placed in a cage with two untreated similar corks and 10 beetles. No attacks were made on any of the corks.

In the laboratory a 30 by 100 millimeter vial filled with alcohol fell on its side and remained there for some time. The cork of this vial was riddled with beetle attacks, at least 12 beetles having bored it.

Oak-bark tea.—Four feet of cable in the "experimental cage" was painted with old oak-bark tea. One hundred beetles were active around it but none appeared to be attracted.

Yeast.—Sections of oak were dipped into various strengths of a yeast dissolved in warm water. Ten beetles were placed with the sections. Apparently these were slightly attracted to the sections dipped in the strongest mixture (2 cakes to one-half quart) and left for the longest time (48 hours).

About all that can be said about these fermentation experiments is that they indicate that at certain times under certain conditions some beetles are attracted. As the conditions of the ferments vary so much and the beetles themselves vary in the same ratio, it is almost impossible to draw reliable conclusions.

Occurrence Experiments.

In order to determine the normal occurrence of the beetles around the regular commercial cables the following experiments were conducted.

Los Gatos.—Four sections of freshly cut oak with the ends dipped in hot paraffin were suspended parallel with the cable in two different locations in Los Gatos. Two sections were suspended near a wood yard which contained beetle-infested wood and the other two about one-half mile away. The sections remained in place from July 25 to October 25. One of the sections suspended near the wood yard was attacked by three different females. The other three sections were not attacked.

Palo Alto.—Similar sections of wood were suspended in the acacia tree close to the cable cages mentioned under "aerial cage" at Palo Alto. No attack was made on these sections. Beetles placed in a small cage with similar sections attacked the sections, so it is reasonable to suppose that if any beetles had been flying near by they would have attacked these sections.

Santa Barbara.—On August 18 about 25 feet of commercial cable at Santa Barbara was covered with a commercial sticky material

used on fly paper and another used for banding trees, about half the length with one and half with the other. The cables were examined about October 1 and a number of insects were found caught. Four of these were adults of the lead-cable borer.

These experiments indicate that the beetles are common enough around the cables to cause the damage accredited to them.[15]

EMERGENCE EXPERIMENTS.

Table 5 gives the results of emergence experiments conducted at Los Gatos, Calif., in 1921.

[15] During 1922, commercial sticky material used on fly paper was placed upon the aerial telephone cables in use in four cities; in each city several localities were selected. This sticky material was placed on the cables in May and June and remained until the season was over in September.

In San Jose, 50 sheets were placed upon the cables, in 5 places, 10 sheets to a place; these sheets were about 15 inches long. Near the tannery in Santa Clara 2 beetles were caught; at Station No. 2, 1 beetle; across from the wood yard where thousands of beetles were reared (Station No. 3) 1 beetle was caught; Station No. 4, no beetles; Station No. 5, 1 beetle; or a total of 5 for San Jose.

In the other three cities, the Pacific Telephone & Telegraph Co. placed the sticky material upon the cables. In Los Angeles, 8 localities were selected and from 1 to 8 sheets placed on the cables; only 3 beetles were obtained and these came from locality B with 7 sheets on the cables.

In Santa Rosa, 4 localities with 6 sheets each were selected; 1 beetle was found on the sheets from locality *a*.

In Monterey, 5 localities were selected, 3 in Monterey, 1 at Carmel Hill, and 1 at Salinas; Monterey No. 4 caught 1 beetle on 8 sheets on the cables and Salinas No. 1 caught 1 beetle on 8 sheets on the cables.

Full data were not received from the telephone company in time to include in this paper.

The results seem to indicate that all along the Pacific coast a few beetles are continually going to the cables in all localities, but nowhere do they appear in numbers. The damage is only incidental and there appears to be no special attraction in the cables to draw the beetles. If the beetles get down between the rings and the cable, the contact causes them to bore; otherwise they crawl or fly off without doing any damage.

TABLE 5.—*Emergence of beetles of the lead-cable borer from infested sections of wood through protective coverings; Los Gatos, Calif., 1921.*

Experiment.	Covering used.	Number of beetles emerged from wood.	Stopped.		Penetrated.	
			Beetles.	How stopped.	Beetles.	What.
	Stearin 25 per cent and paraffin 75 per cent:					
A	1/32 inch thick	43	2	By covering	41	Covering.
B	Do.	[1]0	0		0	
C	1/4 inch thick	39	0		39	Do.
D	1/32 to 1/4 inch thick	7	2	By thick covering	5	1 through thick covering, 4 through thin covering.
E	1/32 inch thick	43	0		43	Covering.
F	Do.	51	3	By covering	48	Do.
	Stearin:					
A	1/16 to 1/4 inch thick	13	0		13	Do.
B	Do.	23	0		23	Do.
C	1/8 to 1/2 inch thick	8	5	By thick covering	3	Thin covering.
D	1/32 inch thick	64	0		64	Covering.
E	Do.	21	0		21	Do.
	Chlorinated naphthalene, No. 1001:					
A	1/32 to 3/8 inch thick	35	17	By thick covering	18	4 through thick covering, 14 through thin covering.
B	1/32 to 1/8 inch thick	25	0		25	6 through thick covering, 19 through thin covering.
C	1/32 inch thick	82	0		82	Covering.
	Finishing wax:					
A	1/16 to 1/4 inch thick	8	0		8	Do.
B	Do.	[1]0	0		0	
C	Do.	[1]0	0		0	
D	1/16 inch thick	6	0		6	Do.
E	Do.	1	0		1	Do.
F	1/32 to 1/16 inch thick	20	0		20	4 through thick covering, 16 through thin covering.
	Saturating wax:					
A	1/32 to 1/16 inch thick	14	0		14	Covering.
B	Do.	47	3	By covering	44	Do.
C	Do.	[1]0	0		0	
D	1/16 inch thick	14	2	By covering	12	Do.
A	Beef tallow, cold, 1/4 inch thick	39	0		39	Do.
	Splicing compound "X":[2]					
A	Fabric side away, 3 to 4 thicknesses	16	16	11 by 1, 5 by 2	5	5 through 1, 0 through 2.
A1	Compound only, 3 to 4 thicknesses	22	22	5 by 1, 15 by 2, 2 by 3	17	17 through 1, 2 through 2, 0 through 3.
B	Fabric next to wood, 4 thicknesses	27	27	15 by 1, after penetrating fabric; 12 by 2, after penetrating fabric.	12	12 through 1, 0 through 2.
B1	Fabric only, 4 thicknesses	16	[3]2	0 by 1, 1 by 2, 1 by 3, 0 by 4	16	16 through 1, 13 through 2, 12 through 3, 12 through 4.

	Splicing compound "Y":					
A	Fabric side away, 2 to 3 thicknesses	4	4	By covering	0	
A1	Compound only, 2 to 3 thicknesses	25	23	6 by 1, 14 by 2, 3 by 3	19	19 through 1, 5 through 2, 2 thorugh 3.
B	Fabric next to wood, 3 to 4 thicknesses	21	21	9 by 1, 11 by 2, 1 by 3	12	12 through 1, 1 through 2, 0 through 3.
B1	Fabric only, 3 to 4 thicknesses	9	0	0 by 1, 0 by 2, 0 by 3, 0 by 4	[4] 9	9 through 1, 8 through 2, 8 through 3, 6 through 4.
	[2] Splicing compounds "X" and "Y," rolled together:					
A	Fabric next to wood, 6 to 8 thicknesses	39	39	6 by 1 X, 26 by 2 Y, 6 by 3 X, 1 by 4 Y	33	33 through 1, 7 through 2, 1 through 3, 0 through 4.
A1	Do	38	38	5 by 1 Y, 21 by 2 X, 12 by 3 Y	33	33 through 1, 12 through 2, 0 through 3.
B	Compound only, 6 to 8 thicknesses	22	22	10 by 1 X, 12 by 2 Y	12	12 through 1, 0 through 2.
B1	Do	22	22	12 by 1 Y, 10 by 2 X	10	10 through 1, 0 through 2.
C	Fabric only, 6 to 8 thicknesses	13	[5] 4	0 by 1, 0 by 2, 0 by 3, 2 by 4, 1 by 5, 1 by 6, 0 by 7, 0 by 8.	13	13 through 1, 13 through 2, 13 through 3, 11 through 4, 10 through 5, 9 through 6, 3 through 7, 3 through 8.
C1	Do	9	2	0 by 1, 0 by 2, 0 by 3, 1 by 4, 0 by 5, 0 by 6, 1 by 7, 0 by 8.	9	9 through 1, 9 through 2, 9 through 3, 8 through 4, 8 through 5, 8 through 6, 7 through 7, 7 through 8.
A	2-inch black friction tape, wound spirally, 1 to 7 thicknesses.	19	[6] 16	1 by 1, 1 by 2, 4 by 3, 6 by 4, 1 by 5, 3 by 6.	18	18 through 1, 15 through 2, 10 through 3, 4 through 4, 3 through 5, 0 through 6.
A1	Black friction tape, 2 thicknesses, crossed	24	[7] 8	2 by 1, 6 by 2	22	22 through 1, 4 through 2.
B	Spread friction tape, No. 1727, wound spirally, 1 to 6 thicknesses	11	[8] 8	0 by 1, 1 by 2, 1 by 3, 1 by 4, 3 by 5, 2 by 6.	11	11 through 1, 10 through 2, 9 through 3, 6 through 4, 3 through 5, 1 through 6.
C	Calendered friction tape, No. 1716, wound spirally, 2 to 4 thicknesses.	8	[9] 5	0 by 1, 1 by 2, 3 by 3, 1 by 4	8	8 through 1, 7 through 2, 3 through 3, 1 through 4.
A	Black rubber insulating compound, 1 to 2 thicknesses	47	[10] 8	0 by 1, 8 by 2	47	47 through 1, 25 through 2.
B	Red rubber insulating compound, 1 to 4 thicknesses	55	[11] 47	0 by 1, 6 by 2, 16 by 3, 25 by 4	55	55 through 1, 47 through 2, 29 through 3, 4 through 4.
C	30 per cent rubber insulating compound	73	73	63 by 1, 10 by 2	10	10 through 1, 0 through 2.
D	Pure gum rubber, 7 thicknesses	37	[12] 37	37 by 1	0	

[1] None emerged at area covered.

[2] Several individual experiments were conducted with two commercial splicing compounds designated as "X" and "Y." Small strips were used over adults which seemed ready to emerge. In some cases the fabric was placed next to the wood and in other cases the compound was so placed. In all cases the beetles emerged.

[3] Two escaped after penetrating first thickness.

[4] One escaped after penetrating first thickness, and 2 after penetrating third.

[5] Six escaped at sixth thickness.

[6] Two escaped at first thickness and 1 at second.

[7] Twelve escaped at first thickness.

[8] Two escaped at third thickness.

[9] One escaped at second thickness and 1 at third.

[10] Fourteen escaped.

[11] Two escaped at first thickness and 2 at second.

[12] Eight of the 37 got one-half through first thickness; 11 got about one-fourth through first thickness.

PROTECTION EXPERIMENTS.

Steel sleeves.—To determine the protective value of steel sleeves placed around the cables within the suspension rings a number of these were placed on a commercial cable at Palo Alto. As no attack was made on the cable in that locality the results are negative.

P. & B. paint.—Many of the old cables used in the city of Santa Barbara have been coated with P. & B. paint. In numerous cases this paint gathered on the underside of the cables, which allowed the beetles to obtain a foothold for boring from it.

WEATHERING TESTS OF PROTECTIVE MATERIALS.

Table 6 gives a list of materials which might be used on the cables to keep the beetles from boring into them. It also shows how the

TABLE 6.—*Weathering tests of materials applied to cables for protection against the lead-cable borer; Los Gatos, Calif., 1920–21.*

Material.	Date examined.	Odor	Color.	Consistence.	Weathering condition.
A	Nov. 30, 1920	Slightly oily or varnishy.	Dark brown, nearly black.	Firm where thinly applied, soft where thickly applied.	Does not hold evenly; has dried out and hardened, except where heavily applied.
	Nov. 24, 1921	Oily	Yellowish brown	Flaky and crumbly	Very little grease left.
B	Nov. 30, 1920	Slightly oily.	Lemon yellow	Soft and pliable	Holds well, has not deteriorated.
	Nov. 24, 1921	Oily	Light yellow	Soft and fairly pliable, smooth.	Still greasy, holds evenly, has deteriorated, but is best of greases.
C	Nov. 30, 1920	Slightly oily	Yellow brown	Soft and fairly pliable.	Holds well; has deteriorated more than B.
	Nov. 24, 1921	Oily	Brownish yellow.	Slightly greasy, flaky.	Some grease in heavy portion, flaky at ends.
D	Nov. 30, 1920	do	Dirty white where thin.	Soft	Not as good as B and C, but better than A; has deteriorated considerably.
	Nov. 24, 1921	do	Yellow to dark brown.	Firm but pliable, not flaky.	Fairly even where thin; some grease remains.
E	Nov. 30, 1920	Musty	Nearly black	Fairly soft	Has hardened somewhat.
	Nov. 24, 1921	do	Dark brown	Powdery, no grease left.	Badly deteriorated.
F	Nov. 30, 1920	Tallowy	Milky white	Soft and pliable	Like day of application.
	Nov. 24, 1921	do	Dirty white	Firm	Holds well, especially where thick.
G	Nov. 30, 1920	Slight paraffin.	Colorless	Firm but pliable	Like day of application.
	Nov. 24, 1921	do	do	Soft and even	Very good.
H	Nov. 30, 1920	Strong naphthaline.	Creamy yellow	Hard, waxy, flakes off where thinly applied.	Appears very good.
	Nov. 24, 1921	Naphthaline.	Yellowish white.	Like firm laundry soap	Very good.
I	Nov. 30, 1920	No odor	Dark brown	Firm, uneven	Some deterioration.
	Nov. 24, 1921	do	do	Firm, hard, waxy	Poor.
J	Nov. 30, 1920	Tarry	Nearly black	Hard where thin, sticky where thick.	Like day of application.
	Nov. 24, 1921	do	do	do	Has changed very little.
K	Nov. 30, 1920	No odor	Black	Hard and smooth, velvety.	Like day of application.
	Nov. 24, 1921	do	Velvety black	Firm and even	Slight deterioration.

weather affected them. The test cable was placed in position September 29, 1920, and thoroughly examined November 30, 1920, and November 24, 1921. The materials to be tested were placed on the cable at the points where it was suspended by the rings. The tallow and

waxes were heated and poured onto the cable; the greases were spread on with a paddle, and the tar and paint were applied with a brush. The materials used were (A to E) commercial greases or petroleum compounds: (F) a mixture of refined paraffin, 50 per cent, and tallow, 50 per cent; (G) refined paraffin; (H and I) two chlorinated naphthalene compounds Nos. 1001 and 1008; (J) pine tar; and (K) P. & B. paint.

The records indicate that the greases (A–E) with the possible exception of B, do not weather as well as the waxes (F–I) and the paints (J and K). The paraffin (G) appears to have held its original qualities best, with H, F, K, J, and I following in the order given.

RESULTS OF EXPERIMENTS IN CALIFORNIA IN 1922.

During the season of 1922 bitumastic enamel, animal gall, pine tar, sealing wax, turpentine and rosin (1 quart to 1 pound), several preparations of mineral paint, pure rubber, tin foil, copper foil, and thin copper sheeting were experimented with as repellents. The only materials that stopped the beetles were the copper foil and copper sheeting and the rubber. Numerous beetles tried the copper but none succeeded in penetrating it. Six beetles out of 32 penetrated one thickness of the rubber and 2 of these emerged. None succeeded in penetrating more than one thickness.

So far as can be determined none of the substances have any repellent value, for the beetles enter wood through them as well as emerge through them. It was felt that the animal gall would repel them, but they attack the wood through it and also through the mineral paints.

Acetic acid and tannic acid, as well as the alcohol, show some attraction to the beetles. One of the telephone men brought in some specimens of Scobicia which he found entering a wine cask.

In the attempt to determine the cause of the beetle's attacking the cable no definite conclusions have been reached. The authors believe that the beetle bores the cable because it finds itself closely confined between the cable and the suspending ring, but they do not believe that it can be proved. If it was drawn to the cable by any other attraction it would have to go to this same point to be able to get a foothold from which to bore, and this makes the proof of the theory difficult. The authors have tried the lead, light, heat, electricity, and color as attractants with negative results; but when two pieces of lead are brought closely together, as by a fold, or a glass plate is placed on a sheet of lead and beetles put between, boring takes place.

It was found that adults of *Scobicia declivis* would attack corks treated with a solution of tannic acid and also those treated with a

solution of acetic acid. Oak wood, the normal host, contains tannin and acetic acid.

Below is an analysis, by the Bureau of Chemistry of this department, of a section of oak wood from California.

TABLE 7.—*Analysis of a section of oak wood from California.*

Determination.	As received.	Moisture-free basis.
	Per cent.	*Per cent.*
Moisture	20.36	....
Total solids	6.57	8.25
Soluble solids	6.29	7.93
Insolubles	0.28	0.32
Non-tans	4.20	5.27
Tannin	2.09	2.66

As nearly as could be judged, catechol and pyrogallol tans were present in nearly equal amounts, pyrogallol probably predominating. Pyrogallol was shown definitely by the acetic acid-lead acetate test. The iron-alum test was rather indefinite. Catechol was shown by the bromide test and by the formaldehyde test.

THE METAL-PENETRATING ABILITY OF THE INSECTS ASSOCIATED WITH THE CABLE BORER.

During the study of the penetrating power of the cable beetle numerous records were made on the penetrating ability of the associated insects and a few other species.

The roundhead *Xylotrechus nauticus* Mann. was able to penetrate all of the alloys used, the carborundum-coated lead, copper-coated lead, and building paper. (Pl. IV, Fig. 4.) It penetrated as many as five thicknesses of lead-antimony alloy and seven sheets of building paper. It made no impression on the sheet zinc or sheet steel. Another roundhead, *Neoclytus conjunctus* Lec., penetrated six thicknesses of the lead-antimony alloy and four of pure lead. It made a slight impression on the sheet zinc, but none on the sheet steel. A third roundhead, *Phymatodes nitidus* Lec., seemed unable to penetrate the carborundum-coated lead, but did penetrate one thickness of the lead-antimony alloy and four coats of spar varnish. The fourth roundhead, *Callidium pseudotsugae* Fisher, made only a slight impression on the lead. One Xylotrechus larva penetrated five thicknesses of copper-coated lead and three coats of spar varnish. A bostrichid larva, *Polycaon stoutii* Lec., penetrated one thickness of copper-coated lead but was stopped by the carborundum-coated lead. A few powder-post beetles, *Lyctus planicollis* Lec., penetrated one thickness of lead-antimony alloy and two thicknesses of lead-antimony and lead-tin together, but many beetles of this species did not seem able to penetrate any of the alloys or the carborundum-coated lead. The predatory clerids were unable to make any impression on the alloys.

SUMMARY AND CONCLUSIONS.

Although the fact is rather astonishing to the layman, insects do considerable damage to various manufactured articles of metal throughout the world. One of the most important of these injuries is that to the lead sheathing of telephone cables in California. This consists of circular holes about 0.1 inch in diameter which penetrate the sheathing. These allow the entrance of moisture, which causes a short circuiting of the wires and the resulting stoppage of service to the public.

The insect causing this trouble is a "powder-post" beetle belonging to the family Bostrichidae. Its technical name is *Scobicia declivis* Lec. Normally it lives in the wood of the live oak and other trees as an egg, larva, pupa, and young beetle for about one year. Periodically some beetles attack the cables during the summer season and cause some damage. Practically all of the boring is done near the point of contact of the cable and the rings which suspend the cable from the messenger strand which supports it. This is done because the beetle must have a foothold from which to attack the cable. It obtains the desired foothold by bracing itself against the ring. As moisture is the immediate cause of the trouble, the damage usually fails to become apparent until the rainy season commences, when there is an accumulation of "troubles" to be located and repaired within a short time.

The experiments conducted to date indicate that the beetle is able to penetrate any lead alloy used as a cable sheathing or any poison or repellent placed on the sheathing. Probably it is able to penetrate the poisons because it does not feed as it bores through. Theoretically, if any grease or grease compound which will soften in the sun when the beetle is most active is placed on the rings it will stick to the beetle and suffocate it when it tries to bore into the cable. Beef tallow appears to be the best grease for this purpose. Layers of friction tape impede the boring and thin sheets of copper, zinc, and steel prevent it. Sleeves of these metals can be placed around the cable at the rings, but the cost probably would be too great for general use. At the present time tallowing the rings is the most promising method of control. During the season of 1921 it was found that the beetles were unable to penetrate pure gum rubber.

No definite results were obtained from experiments with the various types of suspension rings. The beetles in the cages would not enter at any of them. It is believed that the new type of ring, made of flattened steel-wire stock, galvanized, which the telephone companies are now installing, is better from the standpoint of preventing attack by the beetle than the older one.

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INSECTS ATTACKING OR PENETRATING METALS.[16]

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(2) MACLEAY, W. S.

1821. HORAE ENTOMOLOGICAE. v. 1, pt. 2, p. 161–524. London.

Page 193 : Heteropterous Coleoptera feed on inorganic matter.

(3) KIRBY, WILLIAM, and SPENCE, WILLIAM.

1822. AN INTRODUCTION TO ENTOMOLOGY . . . (ed. 4), v. 1, 513 p., 2 pl. London.

Page 235 : Larva of *Callidium bajulus* damages wood of roofs or houses in London ; the adult emerges through sheet lead ⅛ inch thick.

(4) KIRBY, W.

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(5) SOCIÉTÉ ENTOMOLOGIQUE DE FRANCE.

1833. ANNALES, t. 2, Bul. 18 décembre.

Page lxxvi : Observations de M. Audouin sur la faculté que possèdent les Callidies de ronger des crops très durs. M. Émy : "Toitures en plomb . . . percées . . . par des larves de Bostriches" [Roofing penetrated].

(6) ENTOMOLOGICAL SOCIETY OF LONDON.

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Page lxxxiii : Observations of W. Sells on the perforations of the larvæ of *Sirex juvencus*.

(7) DEBRÊME.

1844. COMMUNICATION. *In* Ann. Soc. Ent. Fr. 2 sér, t. 2, Bul. 6 mars.

Page xx–xxi : Notice sur des cartouches des soldats et notament la balle de plomb perforées par des larves d'insectes. [Cartridges wrapped in paper.]

(8) SOCIÉTÉ ENTOMOLOGIQUE DE FRANCE.

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Page XXIV–XXVI : Notice sur des clichés typographiques percés par des insectes (*Apate capucina*) et sur des lames de plomb percées de Cetoines. [Stereotype plates.]

(9) MUNFORD, G.

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(10) HENSLOW, J. S.

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(11) ENTOMOLOGICAL SOCIETY OF LONDON.

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Notice of *Monohammus sutor* boring into lead.

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[16] Prepared by Dr. T. E. Snyder with the assistance of Dr. E. A. Schwarz and Dr. F. H. Chittenden, of the Bureau of Entomology.

(12) SOCIÉTÉ ENTOMOLOGIQUE DE FRANCE.

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(13) HAGEN.

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Bleiplatten von Larven zerfressen.

(14) KOLLAR, V.

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Über die Durchbohrung von Metallen durch Larven; uber Bombyx Cynthia.

(15) LINNEAN SOCIETY OF LONDON.

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(16) ———

1857. ÜBER DAS INSECT [SIREX JUVENCUS], WELCHES DEN FRANZÖSEN WÄHREND DES FELDZUGES IN DER KRIM DIE BLEIKUGELN DURCHGEBOHRT HAT; NEBST EINER MITTHEILUNG ÜBER EINE ANALOGE ERSCHEINUNG IN WIEN. *In* Verhandl. Zool. Bot. Vereins Wien, bd. 7, Sitzungsber., p. 153–155.

(17) VAILLANT.

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Balles de plomb perforées par un insecte (*Sirex juvencus*).

(18) MOTSCHULSKY, V.

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(19) SOCIÉTÉ ENTOMOLOGIQUE DE FRANCE.

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(20) NIEDERRHEINISCHEN GESELLSCHAFT IN BONN.

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(21) RATHVON, S. S.

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(22) HAGEN, Hermann August.

1863. BIBLIOTHECA ENTOMOLOGICA. Bd. 2, 512 p. Liepzig.

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(23) ENTOMOLOGICAL SOCIETY OF LONDON.

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(26) [RILEY, C. V.]

1891. LEAD-BORING INSECTS. *In* U. S. Dept. Agr., Div. Ent., Insect Life, v. 4, no. 1 and 2, p. 81.

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(27) BOUVIER, E. L.

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(28) SCIENTIFIC AMERICAN.

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(33) [SCHWARZ, E. A.]

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(41) [BAKER, C. W. (ed.)]
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(42) SCHULER, Albert.
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(46) LAING, F.
1919. INSECTS DAMAGING LEAD. *In* Ent. Mo. Mag., v. 55, no. 667 (3rd ser., v. 5, no. 60), p. 278–279.

(47) MITSUHASHI, S.
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(48) United States Department of Agriculture.

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Damage by *Scobicia declivis* to aerial lead cables in California.

(49) [Anonymous.]

1919. Can eat through lead. *In* Field and Farm, 34th year, whole no. 1734, p. 10. May 10.

Scobicia (*Sinoxylon*) *declivis.*

(50) Banks, Nathan, and Snyder, Thomas E.

1920. A revision of the nearctic termites. U. S. Nat. Mus. Bul. 108. 228 p., 35 pl., 70 figs. Literature cited or read, p. 197–206.

Plate 6: "Lead cable sheathing underground damaged by *Coptotermes,* species, in Panama."

(51) [Brown, W. H. (ed.).]

1920. Telephone cables damaged by wood borers. *In* Agr. Gazette N. S. W., v. 31, pt. 5, p. 344. May.

A suspension of the telephone service was caused by water reaching the wire through small holes bored by the beetle, *Bostrychus cylindricus.* Cables have frequently been attacked in the same way, and an instance of similar injury due to another Bostrychid has already been noted (Froggatt, 45). *B. cylindricus* is one of the commonest Australian wood-boring beetles, attacking all kinds of timber; but the larvae usually feed and pupate in the sapwood. The beetle has been recorded as damaging empty wine-casks. The boring in lead seems to be casual, and no practical method of dealing with it has presented itself, except to destroy any poles, etc., in which the larvae were found to be breeding in any numbers.

(52) Child, Allen P.

1920. The "short-circuit" bug of California. *In* Scientific American, v. 123, no. 26, Dec. 26, p. 637. 1 fig.

Scobicia declivis.

(53) Scott, Hugh, and Laing, F.

1920. Insects damaging lead and other metal-work. Insects damaging lead: Supplementary note. *In* Ent. Mo. Mag., v. 56, 3rd ser. v. 6, No. 61, no. 668, p. 10–12. January.

(54) Snyder, Thomas E.

1920. The lead cable borer. *In* Jour. Wash. Acad. Sci., v. 10, no. 20, p. 580. Dec. 4. (Author's abstract, lecture March 20, 1920, Proc. Biological Soc. Wash., 609th meeting.)

General discussion of the damage to metal by boring insects and especially by *Dermestes vulpinus* Fab. to tubular lead telephone fuses and by *Scobicia declivis* Lec. to the lead sheathing of aerial telephone cables in California. Discussion of remedies and preventives; an effective *permanent* preventive has not yet been discovered.

(55) Felt, E. P.

1922. Wormy timber costly. *In* Jour. of Forestry, v. 20, no. 3, p. 321.

Timbers infested by horntails in new sulphuric acid factory near Saarau, Silesia; adults emerged through lead floor plates, causing loss of 100,000 marks.

THE CALIFORNIA LEAD-CABLE BORER, SCOBICIA DECLIVIS LEC.[17]: BIOLOGY AND TAXONOMY.

(56) Duftschmid, Caspar.

1825. Fauna austriae, pt. 3, 289 p. Lenz and Leipzig.

Page 85: Sinoxylon described.

[17] Prepared by Dr. T. E. Snyder with the assistance of Dr. E. A. Schwarz, Dr. F. H. Chittenden, and Mr. W. S. Fisher, of the Bureau of Entomology.

(57) Société Entomologique de France.

1845. ANNALES, 2 sér., t. 3, Bul.

Page xvii: Xylopertha described by Guérin-Méneville.[18]

(58) LeConte, John T. (i. e. John L.)

1860. REPORT UPON INSECTS COLLECTED ON THE SURVEY. ZOOLOGY 47TH PARALLEL. *In* Reports of explorations and surveys . . . for a railroad from the Mississippi River to the Pacific Ocean. 1853–1855. v. 12, bk. 2, pt. 3, no. 1, 72 p., 2 pls.

Page 48: *Sinoxylon declive:* Original description.

(59) Horn, George H.

1878. REVISION OF THE SPECIES OF THE SUBFAMILY BOSTRICHIDAE OF THE UNITED STATES. *In* Proc. Amer. Phil. Soc., v. 17, p. 540–592.

Same generic and tribal arrangement of *S. declive* as LeConte.

(60) Comstock, J. Henry.

1881. REPORT OF THE ENTOMOLOGIST FOR 1880. *In* Ann. Rept. U. S. Dept. Agr. 1880, p. 235–373.

Page 274–275: Wine cask borers. "In India *Tomicus* [*Xyleborus*] *monographus* is stated by Morse to do great damage by drilling holes in malt-liquor casks, the custom being to destroy the beetles by submerging the casks in boiling water. In California *Sinoxylon declive* Lec. has similar habits. Oak, chestnut, pine, whitewood, and eucalyptus wood have all been used in making casks with a view to discovering some substance which would prove distasteful to the beetles, but without success. Dr. Rivers, curator to the Museum of the University of California, has, however, succeeded in making a cask apparently beetle-proof by saturating the outside with a strong solution of alum water applied while hot, and, as soon as dry, painting with linseed oil. The cask thus treated remained unharmed by the beetles while others were riddled."

(61) Rivers, J. J.

1886. CONTRIBUTIONS TO THE LARVAL HISTORY OF PACIFIC COAST COLEOPTERA. Bul. Calif. Acad. Sci., v. 2, no. 5, p. 63–72.

Page 68: "*Sinoxylon declive* Lec. Any dead tree or unpainted wood, very partial to wine casks and oak barrels. The depredations are done by the beetle while boring for a suitable place to deposit its eggs. Its burrow is straight across the grain of the wood, reaching the interior of the cask, causing waste and deterioration of the contents. Hot solution of alum applied to the outside of the casks will prevent boring."

(62) ———

1887. THE OAKS OF BERKELEY AND SOME OF THEIR INSECT INHABITANTS. 12 p. Sacramento.

Page 11: Attacking dry lumber, particularly oak, and especially oaken wine casks, "inflicting a loss of many thousands of dollars annually to the wine interest."

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[18] Xylopertha was described by Guérin-Méneville (*57*), and Lesne in his monograph of the Bostrichidae (*66, p. 528–529*) includes three species, as follows: *crinitarsis* Imh., from Africa; *picea* Ol., from Africa and also imported into South America; and *scutula* n. sp., from Africa.

Casey (*65*) places *declivis* Lec. in the genus Xylopertha with the following remarks: "*Xylopertha* is confined, as might be expected, to the subsiberian fauna of the Pacific coast, where it is represented by *bidentata, declivis* and *suturalis*, hitherto placed in *Sinoxylon*, which genus has the two basal joints of the antennal club short and transverse."

In 1900, Lesne (*66, p. 584–587*) erected the genus Scobicia and included the following species: *pustulata* Fabr., *barbata* Woll., *barbifrons* Woll., *chevrieri* Villa, *ficicola* Woll., *suturalis* Horn, *declivis* Lec., and *bidentata* Horn. The genus is distributed through North, Central, and South America, Mediterranean regions of Europe and Africa, Egypt, Syria, Madeira, and Canary Islands.

(63) COQUILLETT, D. W.

1892. NOTES ON THE HABITS OF SOME CALIFORNIA COLEOPTERA. *In* U. S. Dept. Agr., Div. Ent., Insect Life, v. 4, nos. 7 and 9, p. 260–262, March.

Notes on hosts and biology of *Sinoxylon declive.*

(64) WICKHAM, H. F.

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Page 597–599: *Scobicia* [*Sinoxylon, Xylopertha*] *declivis* Lec., host trees, geographical distribution—Scobicia described.

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Page 239, footnote 142: Hosts and abundance noted.

APPENDIX.

TAXONOMY AND MORPHOLOGY OF THE LARVAL STAGES OF SCOBICIA DECLIVIS LECONTE.

By Adam G. Böving.

Scobicia declivis LeConte belongs, according to the characters of the larval stages, to the family Bostrichidae. In the recently published Catalogue of the Coleoptera of America North of Mexico, 1920, by Charles William Leng, the genera Polycaon and Psoa are placed in the tribe Psoini of the Bostrichidae but, according to the larvæ, these genera form, together with the genus Stephanopachys (species investigated: *S. substriatus* Payk. and *S. pacificus* Csy.), which Leng places in the tribe Bostrichini, a well defined family, the Psoidae. This latter family is close to the Lyctidae and, like this family, distinct from the Bostrichidae by having a strong epipharyngeal chitinization, a mandible with a large pseudomolar process, and a large fleshy retinaculum. The larvæ of the other genera listed by Leng in the Bostrichidae substantiate the correctness of his conception of that family.

The larvæ of the Bostrichidae (in the present limitation) may be characterized as follows:

Bostrichidae.[19]

Habitus: Generally rather small, whitish, fleshy. Cyrtosomatic (curved like a scarabaeid larva) in all stages except the first in which it is orthosomatic (straight, with dorsal and ventral surfaces approximately of the same size). Legs, or in first stage rudiments of legs, present; no movable claw separated from tarsus. With plicate, never shield-bearing thoracic and abdominal terga. Ampullæ not present; terga never asperate, with or without soft hairs. Ten visible abdominal segments. Ninth abdominal segment well developed, rounded, unarmed in all stages, except the first in which it is armed with an unpaired, chitinous, mucronate tail appendage or spur. No paired cerci. Tenth abdominal segment small, entirely below ninth; anal opening longitudinal.

Head capsule: Head deeply retracted into prothorax, porrect; with subrectangular outline, free portion subglobular. Occipital foramen ventral and opposite frontal region. Frons indistinct; clypeus and labrum present, labrum movable. Epicranium with rather short and curved hypostoma between mandibular condyle and end of cardo; part behind cardo large. Definite gular region not developed, submentum and the prothoracic presternal skin continuous.

Buccal cavity: Hypopharyngeal bracon absent. Hypopharynx fleshy; maxillular areas elongate, soft, each with a longitudinal series of setæ. Epipharynx soft.

Tentorium: Broad and strong.

Ocelli: Not developed.

Antenna: Of medium size or small.

Mouthparts: Mandible gouge-shaped, inner surface subtetragonal, neither with a true molar structure nor with pseudomolar process; no retinaculum; no accessory mandibular condyle. Ventral mouthparts somewhat retracted. Maxillary articulating area present. Cardo flat, quadrangular, not divided, retracted below stipes. Stipites maxillæ anteriorly convergent, connected with maxillary articulating area and hypostoma. Maxillary mala divided into a

[19] This family characterization, as well as the taxonomic remarks given above, is part of a joint study on the characterization of the coleopterous families according to their larval stages, undertaken by Dr. F. C. Craighead and the author.

large, fleshy, hairy outer lobe (galea?) and a stylus-like process (lacinia?). Palpiger maxillæ large, conical, jointlike. Palpus maxillaris two-jointed. Submentum large, separated from mentum by indistinct line. Mentum laterally free or almost free. Stipites labii fused; no distinct palpiger labii: chitinous, narrow, transverse line between stipites labii and mentum. Ligula (united labial malæ) present, ventrally and dorsally undivided.

Thorax: Prothorax dorsally simple; with oblique chitinous rod imbedded laterally in tergum above and in front of first spiracle. Mesothorax and metathorax dorsally duplicate. No hypopleural chitinization at base of legs. Legs, when well developed, of medium size, four-jointed, hairy, with tarsus claw-shaped and concavity facing forward, widely separated by intermediate broad sternum.

Abdomen: Typical (anterior and median) segments dorsally triplicate.

Spiracles: Bilabiate; first spiracle above anterior margin of mesosternum, somewhat larger than the following eight abdominal spiracles, which are all of same size, all lateral, and all placed at lower margin of the terga.

Habits: Wood-boring and wood-feeding.

Relationship to other families: Close to the larvæ representing the Anobiidae, Ptinidae, Psoidae, and Lyctidae. Also connected with the Donaciidae as well as with the Sagridae and Bruchidae by identity of several important morphological structures. The peculiar adaptation of the maxillary mala for sap-sucking in the Donaciidae can, through the construction of this part in the Plateumarini, be derived directly from the stylus-bearing mala in the Bostrichidae. This characteristic stylus formation occurs also in all the Dermestidae. In several genera of this latter family is also found a thick interior enforcement of the mandibular biting surface which corresponds to a similar development in the mature bostrichid larva.

SCOBICIA DECLIVIS LECONTE.

(Larvæ of different stages in U. S. National Museum, Washington, D. C., labeled Hopk. U. S. 16178a4; from Los Gatos, Calif.; collected and reared from eggs by R. D. Hartman.)

The larva of *Scobicia declivis* has six stages. In the first stage several characters are exhibited deviating from those hitherto considered typical in bostrichid larvæ. A full description will be given of only the mature larva and this description will precede the references to the other stages.

GENERAL DESCRIPTION OF MATURE LARVA.

Pl. I, Figs. 1–16; Pl. II, Figs. 17–32.

Length of larva: About 10 millimeters, width 2.50 millimeters. Straight line between head and anus, when larva is curled, 6.85 millimeters. Length of the combined thoracic segments in proportion to length of the combined abdominal segments about as 1 : 2½ (measured on imaginary lateral line through the spiracles). Largest vertical diameter of head in proportion to largest vertical diameter of prothorax, about as 1 : 3.

Head capsule (Pl. II, Figs. 17–19): Formed by fusion of frons and epicranium; elongate, subrectangular with rounded corners, twice as long as wide; almost two-thirds retracted into prothorax; whitish with heavy dark brown chitinization anteriorly on each side. This chitinization is constituted by the lateral part of epistoma (*e*, Pl. II, Fig. 17), the entire pleurostoma (*p*, Pl. II, Fig. 21), the entire hypostoma between mandibular condyle and end of cardo (*h*, Pl. II, Fig. 19), and by a triangular region extending posteriorly and laterally from hypostoma as far back as the posterior margin of the tentorial bridge (Pl. II, Fig. 19). It supports the clypeus and the mandible, is adjacent to the exterior part of the maxilla, and surrounds the antenna, separating the antennal basal skin from the mandibular connecting membrane (Pl. II, Fig. 21). Exposed parts of head capsule roughened by numerous granules and set with light fine hair all over the surface; a series of setæ present, reaching from antennal base obliquely upward and backward.

Foramen in middle of ventral surface of head capsule: Elongate oval, almost one-third as long as capsule; posteriorly and laterally limited by sharply infolded margins of epicranium, anteriorly by tentorial bridge (*tb*, Pl. II, Fig. 19).

Sutures: Distinct frontal sutures obliterated. Epicranial suture concealed by prothorax when head is in natural position, three times as long as width of clypeus; anterior two-thirds of suture (*cs*, Pl. II, Fig. 17) dorsal, posterior one-third (*cs*, Pl. II, Fig. 19) ventral, situated on recurved hind part of cranium.

Clypeus (Pl. II, Fig. 28): Oval, transverse; one-third as wide as cranial capsule, one-third as long as wide, slightly chitinized on each side of median oval part which is pure white; posterior margin of chitinized parts densely set with fine, light setæ about as long as length of clypeus.

Labrum (Pl. II, Figs. 28, 31): Transverse, obovate, with each posterior corner invaginated forming a slender chitinous process; entire width of labrum to width of cranial capsule as 1:4; length to width about as 1:3; slightly chitinized; disk divided by two parallel, longitudinal, straight bands into three divisions; median division somewhat larger than each lateral; entire anterior margin and the lateral divisions densely set with well developed, slightly pendent, brown setæ, about half as long as length of labrum.

Antenna (Pl. II, Fig. 28): About as long as length of clypeus, three-jointed, borne by large, conical basal skin. Basal joint cylindrical, about one-third the length of entire antenna; as wide as long. Second joint cylindrical, somewhat longer and narrower than basal joint. Apical joint conical, a little shorter than basal joint, half as wide as long. Corresponding to a supplementary joint, a small round spot ventrally near foot of apical joint. Basal joint anteriorly with a few short setæ; apical joint with single minute seta at the tip and a minute seta at the base.

Mandibles (Pl. II, Figs. 23–26): Strong, short, about one-fourth the length of cranial capsule; cuneate, with inner and outer surfaces subtetragonal, dorsal and ventral surfaces subtriangular; length, depth, and width almost equal. Inner surface apically with transverse cavity, about four times broader than long, anteriorly and laterally limited by sharp, thin, perlucid, slightly rounded edge, posteriorly gradually sloping down into median portion of inner surface. Median portion about twice as long as apical portion, transverse, subtrapezoidal, flat, longitudinally rugose. Posterior portion of inner surface transverse, about as long as apical and median together; outline irregularly rounded, disk with a few large, low lobes and with a large, globular, chitinous protuberance on side of the interior wall (Pl. II, Fig. 24, showing a longitudinal section of inner wall of mandible). Margin below posterior portion thick, heavily chitinized; projecting into the mandibular internal cavity; carrying a little trapeze-like process. Exterior, dorsal, and ventral mandibular surfaces smooth and shiny. Fossa and condyle large. Color of mandible black, base reddish brown; no setæ.

Maxilla (Pl. II, Figs. 27, 29): Outer lobe of mala (galea?) cushionlike, with round outline and somewhat flattened, about twice as large as palpiger (*pg*); dorsally (Pl. II, Fig. 20) and ventrally hairy, with several large setæ. Inner lobe (lacinia?) ventrally enforced and almost completely represented by a slender chitinization, twice as long as outer lobe and almost as long as stipes, anteriorly not reaching far beyond base of outer lobe, posteriorly reaching chitinization along inner margin of stipes; anterior half of chitinization of inner lobe stylus shaped; posterior half heavier and C-shaped. Stipes fleshy and about as large as the lobes and palpiger together; along inner margin with thin, light chitinous band which is broadest and strongest posteriorly where cardo hinges; fine, long setæ from antero-external surface. Maxillary palp slightly projecting beyond exterior maxillary lobe; two-jointed, borne by large, jointlike palpiger. Palpiger somewhat smaller than outer lobe; at base with chitinous setose half ring; at top on ventral surface with transverse series of setæ. Palpus as long as palpiger and about half as long as antenna; basal joint almost as long as thick, with a few minute setæ; apical joint as long, half as thick as basal joint, with small tactile papillæ on top (compare Pl. I, Fig. 5). Cardo (c, Pl. II, Fig. 27) rhomboidal, flat, chitinized; vertically placed against ventral surface of stipes; when at rest, concealed (Pl. II, Figs. 19 and 29).

Maxillary articulating area (*ma*, Pl. II, Figs. 29 and 19): Fleshy, almost as large as mala, connecting stipes and submentum.

Submentum (*sm*, Pl. II, Fig. 29): About as long as stipes; transverse, parabolic, twice as wide as long (Pl. II, Fig. 19), fleshy.

Mentum (*m*, Pl. II, Figs. 29 and 19): As long as submentum, not much wider than long; free, fleshy.

Stipes labii (*stl*, Pl. II, Fig. 29): Transverse, elongate, oval; length to width as 1:4; width to width of mentum as 4:5. Separated from mentum by a

chitinous, posteriorly convex band. No distinct palpiger labii. Palpus labii with two joints, proportioned as those of the maxillary palpus, but only two-thirds as long and wide as these.

Ligula (*li*, Pl. II, Figs. 29 and 20): Triangular, as long as stipes labii, as wide as long. Ventral surface fleshy, setose. Dorsal (buccal) surface finely papillose; both ventral and dorsal surfaces simple, unpaired.

Maxillular area (=paraglossa=paragnatha auctorum) (*mxl*, Pl. II, Fig. 20): Paired, elongate, membranous, slightly lobate, near median line with a longitudinal series of densely set, short setæ. Between the two maxillular areas, a narrow, slightly chitinized, longitudinal groove.

Hypopharynx (*hyp*, Pl. II, Fig. 20): Membranous, nude, without chitinization on the upper surface. On the underside of the skin with unpaired, elongate, sling-shaped, anteriorly somewhat narrower thickening; possibly corresponding to a pair of transversely connected hypopharyngeal rods.

Epipharynx (Pl. II, Fig. 31): Membranous, anteriorly and laterally with medium long setæ; median disk nude. Epipharyngeal rods (*cr*) well developed.

Legs (Pl. I, Fig. 16; Pl. II, Fig. 30): Three pairs; each pair widely separated by intermediate sternal region; all four-jointed, well developed, not fully of medium size; total length and length of individual joints almost the same for all pairs and equal to the height of head; anterior pair somewhat stronger and thicker than the two posterior ones. All legs whitish with strongly chitinized, dark brown, claw-shaped tarsus. Coxa conical, projecting, with base twice as wide as top; length equal to diameter of base and about one-fifth of the length of the entire leg; ventrally with long setæ. Trochanter not distinct. Femur subcylindrical, laterally somewhat flattened; twice as long as coxa, twice as long as thick; ventrally and laterally with numerous long, soft hairs. Tibia of front leg (Pl. II, Fig. 30) obovate, laterally somewhat flattened, bent at base; tibiæ of the other legs cylindrical and straight at base; length of front tibia in proportion to length of front femur as 2:3, lengths of the other tibiæ in proportion to the lengths of corresponding femora as 1:1; front tibia slightly narrower than front femur; the other tibiæ as thick as the corresponding femora. Long, dark brown hairs, densely scattered over the entire surface. A tibial spine present in front of claw-shaped tarsus; largest on prothoracic tibia. Claw-shaped tarsus inserted posteriorly on tip of tibia; curved with concavity forward.

Body form (Pl. I, Fig. 16): Curved, clavate, cylindrical, gradually thickening from middle of abdomen toward prothorax; prothorax approximately hemiglobular. Body about four times as long as the median abdominal segments are high; greatest height of thoracic segments one-half more than the height of the median abdominal segments. Epipleural lobes ventrally swollen and on the median body segments with numerous light brown hairs tuftlike or gathered together.

Body chitinizations and color[20]: Dull white to light yellow, no chitinous parts, except the oblique lateral prothoracic rod. Anterior and ventral end of this rod distinguished by a light brown spot in front of the thoracic spiracle, posterior and dorsal end marked as a dark brown line gradually tapering into the middle of the side of the segment; the intervening rest of the rod colorless. On the feeding larva the digestive tract shows through the tergites as a colored line which varies from cream to dark red according to the nature of its host. This line tapers posteriorly from the first abdominal tergite, recurving in hook shape on the lateral margins of the last two terga.

Body areas (Pl. I, Fig. 16): Cervical region with large presternal area; prothorax with only a single distinct dorsal area; mesothorax and metathorax with two dorsal areas (prescutum and the united scutum and scutellum); the first five abdominal segments with three dorsal areas (prescutum, scutum, scutellum); the sixth with two (prescutum and the united scutum and scutellum); the seventh to ninth segments with undivided dorsum. Seventh to ninth abdominal terga slightly hairy in a transverse belt along the posterior margins of the segments; terga of the other segments smooth and naked.

Ninth abdominal segment: Rounded, longer than eighth; without armament of any sort.

[20] This paragraph on body chitinization and color is copied from notes containing good descriptions after living material with exact measurements of the different larval stages given the author by R. D. Hartman for free use in preparation of the present study. (A. G. B.)

Tenth abdominal segment: Much smaller than ninth, hardly one-fifth its size; truncate. Anal opening (Pl. I, Fig. 16) longitudinal; between two oval anal lobes.

Spiracles (Pl. II, Fig. 32): Nine; bilabiate, with slightly chitinized peritreme; elongate oval, more than three times as long as wide; longest diameter extending dorso-ventrally. Spiracular opening set all around with stiff, hairlike spines reaching half way to opening's longest diameter. First (mesothoracic) spiracle larger than the rest; located in the epipleurum of prothorax. Abdominal spiracles all of same size and all placed alike, near lower margin of terga.

Body movements:[21] Very active.

Remarks Referring to the Deviating Morphological Structures of the First-Stage Larva.

Pl. I, Figs. 1–7, 9–12.

Length of larva: Three-sevenths the length of the egg; same width as egg. Average length without spine, 0.76 millimeter; with spine, 0.83 millimeter; length of exposed part of head, 0.10 millimeter. Width of head, 0.17 millimeter; of prothorax, 0.36 millimeter; of the middle of body, 0.24 millimeter; of ninth abdominal segment, 0.10 millimeter.

Labrum (Pl. I, Fig. 3): Subtriangular, divided as in mature larva by two longitudinal, parallel bands into three divisions. Setæ straight, comparatively longer than in mature larva, fewer than in this.

Antenna (Pl. I, Figs. 2 and 4): Very short, consisting of a flat and ovate basal membrane carrying a single small joint (*a*) with a separate low basal ring (*b*) and a slightly smaller supplementary joint (*c*).

Mandible (Pl. I, Fig. 4): Apex formed by two flat, blunt, curved, anteriorly converging, toothlike thickenings of almost equal size and shape, one thickening dorsal (*a*), the other ventral (*b*), united by a thin chitinous wall (*c*), possibly corresponding to the thin wall of the anterior mandibular cavity in the mature larva. Biting surface (*d*) flat, disklike, with free, slightly projecting anterior and lateral margins. Color of entire mandible light brown.

Ventral mouthparts (Maxilla, labium, mentum, and submentum) (Pl. I, Figs. 4, 5, 6): All essential morphological features as in mature larva; the proportions of the different structures, however, somewhat deviating; the comparatively large size of ligula (*li*, Pl. I, Fig. 6) especially noticeable.

Legs (Pl. I, Figs. 10, 11, 12): Very reduced. First pair (I) with two indistinctly separated joints; about five setæ. Second pair (II) wart shaped; with two setæ. Third pair (III) almost absent, represented by minute conical elevation of the skin; with one small seta.

Body form (Pl. I, Fig. 1): Orthosomatic, clavate-cylindrical, tapering from prothorax; rates of height of thorax to height of an average abdominal segment as 4:3. Dorsally plicate, with plicæ arranged as in mature larva.

Body color, chitinizations, and setæ (Pl. I, Fig. 1): Shiny white, with granulated appearance. Soft; chitinous rod present on prothorax. No setæ.

Ninth abdominal segment (Pl. I, Fig. 7): Dorsally longer than eighth. Terminal half armed with chitinous and yellowish, unpaired, depressed, triangular tail spur, at end abruptly truncate and on each side posteriorly serrate; a few scattered setæ.

Tenth abdominal segment (Pl. I, Fig. 1): Completely covered by armed ninth. Anal opening, a longitudinal slit.

Body movements: Sluggish.

The most striking characters of the first-stage larva are the orthosomatic body shape, the apparently apically bilobed mandible, the rudimentary legs, and the tail spur on the ninth abdominal segment.

According to recent observations by Dr. T. E. Snyder on the different stages of *Lyctus planicollis* Lec., corresponding characters are found in the first-stage larva of this genus, namely, a straight, orthosomatic body as compared with the curved cyrtosomatic body of the other stages, rudimentary legs as compared with the well developed legs of the other stages, and, instead of an unpaired tail spur as in *Scobicia*, a pair of short, conical, slightly upward curved, pointed

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[21] For further information on the habits of the different larval stages see pages 15–16.

cerci on the dorsal side of the ninth abdominal segment; the other larval stages of *Lyctus planicollis* Lec. being without armature. (Pl. I, Fig. 8 sketched by Dr. Snyder from a larva in balsam mount reared from the egg; showing ninth abdominal segment from the end, placed in somewhat oblique position to exhibit both of the cerci and at the same time give a view of their lateral outline.)

Second and Following Larval Stages.

Pl. I, Figs. 13, 14, 15.

In the general aspect and the shape and proportions of the morphological details, the second larval stage is only slightly different from the mature larva, which may be seen by a mere comparison of Pl. I, Figs. 13–15 with the corresponding figures of the mature form. The following stages also are almost identical with the mature larva, except in size and minor details.

SECOND LARVAL STAGE.

Length: 0.56 millimeter; width, 0.21 millimeter; length in proportion to length of first stage larva (Pl. I, Fig. 9 drawn with same magnification as Pl. I, Fig. 13) as 3:4; width as 4:3.

Head capsule: With few setæ.

Labrum: Not densely set with setæ.

Mandible: Brown.

Maxillary outer lobe and ligula: Not densely covered with setæ.

Legs: First pair with five setæ. Second pair with three. Third pair with two setæ.

Body form, color, and setæ: Slightly curved. Epipleural lobes not developed. Dull white. Few setæ dorsally on the posterior abdominal segments.

Body movements: Active.

THIRD LARVAL STAGE.

Head capsule: With more setæ than in preceding stage.

Labrum: Distally covered with numerous light brown setæ.

Mandibles: Dark brown.

Maxillary outer lobe and ligula: Covered with numerous setæ.

Legs: First pair with 7 setæ on femur; 8 to 10 on distal end of tibia; tibial spine developing near claw-shaped tarsus. Second pair with 1 seta on femur; 5 on tibia; tibial spine developing. Third pair with no setæ on femur; 4 on tibia; tibial spine developing.

Body form, color, and setæ: Curved. Epipleural lobe developing. Dull white. Posterior abdominal segments more hairy than in preceding stage; epipleural lobe with a few setæ.

Body movements: Active.

THE FOURTH AND FOLLOWING LARVAL STAGES.

These stages differ from the third stage by darkening of mandibles and chitinization on ventral mouthparts; by presence of more and coarser setæ on femora and tibiæ; by stronger development of tibial spines; by more curved form; by a stronger coloring of chitinous rod of prothorax; by more prominent epipleural lobes with additional setæ. Body movements are very active.

Body proportions of a medium sized larva: Length, 5 millimeters; width, 1.75 millimeters; distance between head and anus when curled, 3.50 millimeters.

Prepupal larva: Length, 8 millimeters; width, 2.75 millimeters. Creamy white or light yellow. Straightened and more active.

DESCRIPTION OF THE MATURE ADULT OF SCOBICIA DECLIVIS LEC.

By R. D. Hartman.

GENERAL DESCRIPTION.

Form cylindrical, head deflexed; size small (average length, 5.85 millimeters; average width, 2.10 millimeters); the prothorax and abdominal sternites about

equal in length. Color dark brown to black, mostly black; antennae, mouthparts (except mandibles), femora, and tarsi light amber; tibiæ, posterior lateral area of prothorax, and tumid area on the anterior lateral portion of elytra dark amber.

DETAILED DESCRIPTION.

Head: Rugose, globular, deeply evaginated into prothorax, tapering caudad and cephalad from its center. Eyes convex, prominent, elevated from head caudad, possibly for reception of prothoracic margin when head is strongly reflexed. Antennæ inserted in front of eyes, 9-jointed, with a 3-jointed club, last joint oblong, appearing slightly longer than joints 7 or 8, joint 7 broadest and prominently flanged, intermediate joints 3, 4, 5, and 6 shorter than joints 1 and 2 combined. Gula distinctly outlined. Clypeus indistinct. Labrum wedge-shaped, broader than long, distal margin covered with heavy tuft of light brown hairs. Mentum and submentum divided by distinct suture, of same width at suture, the former longer than broad, tapering toward ligula; latter broader than long, tapering toward gula; submentum heavily chitinized. Maxillary palpi 4-jointed, basal shortest, distal longest. Galea and lacinia prominent, hairy. Labial palpi 3-jointed; basal short, confluent; distal elongate, tapering from its base. Mandibles simple, moderately pointed, gradually widening dorsally and bearing on the inner margin toward the base a small molar tooth. Beginning at the base of each mandible a semicircle of dark brown hairs extending very prominently over the front.

Prothorax: Pronotum as broad as long, cephalic margin smooth and truncate, caudal slightly flanged and circular, anterior lateral area bearing a number of strong rasplike tubercules, these diminishing in size dorso-posteriorly; posterior lateral area smooth, shiny, and testaceous. Prosternum occupied mostly by coxal cavities; much broader than long, giving the prothorax a hood-like shape. No marginal lines.

Mesothorax: On the mesonotum the prescutum is a triangular sclerite with the scutellum plainly exposed. Mesosternum also triangular, but reversed from prescutum; the poststernellar piece separates the coxæ while the cephalic aspect of the sternum nearly reaches the prosternal margin but is prevented by the episternal sclerites joining at this point; these large sclerites bear numerous indistinct, irregular punctures. The episternum and prescutum are separated by the subcostal head.

Elytra: Entire, striæ irregular, punctures larger dorso-posteriorly; two rather inconspicuous costæ on each elytron anteriorly, the dorsal costa gradually joining the sutural margin which forms an acute tooth near the apex of the obliquely truncate declivity. Sutural striæ deeply impressed posteriorly but not entering the declivity. Declivity smooth and shiny between the prominent sutures, bearing very small light brown hairs. Lateral margin gradually undate near the middle, a tumid area on each elytral shoulder, color dark amber; balance of elytra piceous.

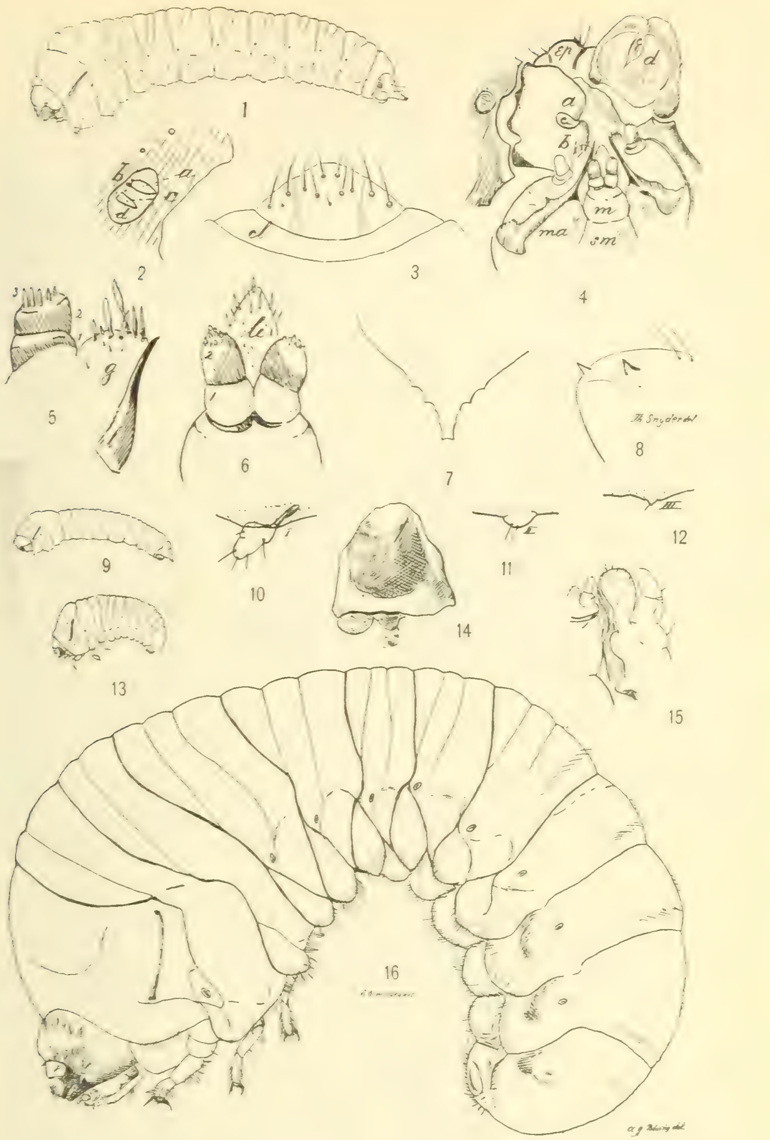
Metathorax: Metatergal groove distinct, arrow-shaped; scutellum prominent; postscutellum with a median emargination partially covered by the first abdominal tergite. Metasternum longer than either the prosternum or mesosternum, no distinct median line; sternal and episternal sutures clearly outlined, episternum elongate. The sternellar piece is divided for the reception of the intercoxal process. (The sternellar area and third abdominal sternite are grooved for the reception of the hind femur.)

The metathoracic wings are rather interesting in their length, venation, and the method by which their apex is folded when at rest. The subcosta soon parallels the costa, making a wide dark chitinized outer margin, while the radius dips well into the center and one branch joins the costa and subcosta at about two-thirds the length of the wing (this being nearly the length of the elytra), the veins showing a heavy elevated chitinization at their junction and forming a large closed cell that corresponds with the ventral aspect of the elytron, the other two branches of the radius joining the anal angle to strengthen the wing; the area toward the apex bears two veinless chitinizations which seem to act as weights that assist in properly folding the wings when not in flight.

Legs: Coxæ of anterior and middle pair globular; posterior coxa with a long, tapering, transverse sclerite terminating near the episternal suture; anterior pair contiguous, middle pair separated by the sternellum, and posterior pair by the intercoxal process. Trochanters small, without trochantins. Femora slightly swollen, pale testaceous, grooved at the distal inner margin for the reception of the tibia. Tibiæ slender, about same length as femora, dark amber.

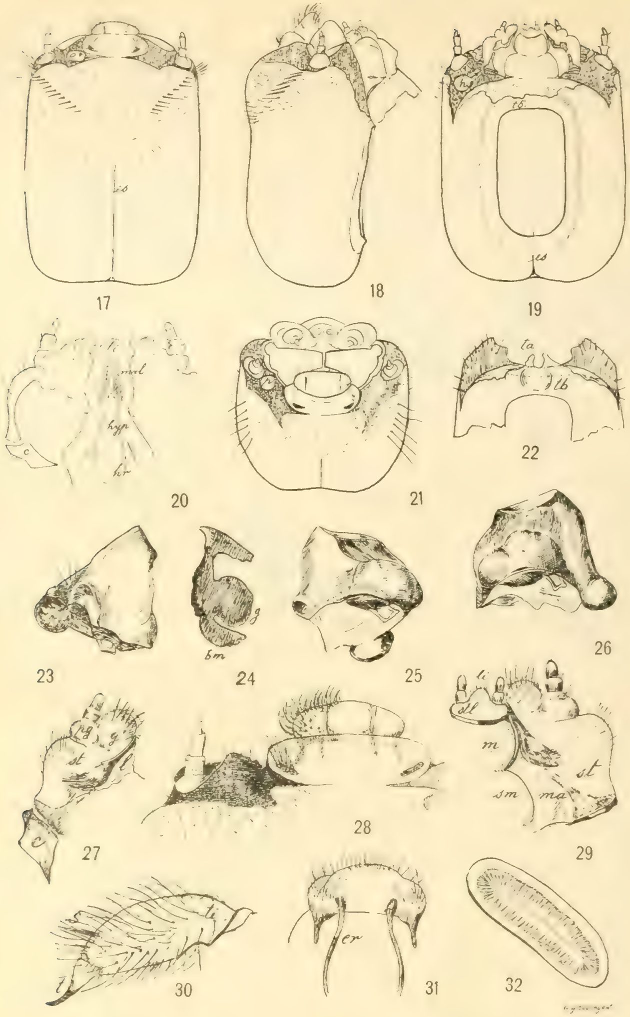
external margin serrate; anterior pair terminating in a hooklike spur, the middle and posterior pairs differing in having two tibial spurs. Tarsi 5-jointed, first joint very short, last longest, distal end bearing simple claws.

Abdomen: Tergites eight, first longest, anal or pygidium nearly quadrate, intermediate about equal in length. Spiracles seven, first much the largest. Sternites eight, 1 and 2 hidden by the sternellar area, 3, 4, 5, 6, and 7 plainly visible and sparsely covered with fine light hairs, 3, 4, 5, and 6 varying but little in length, 3 being largest, 7 and 8 differing as to sex. In the male the seventh sternite has distinct pleural pieces, anal end truncate, while in the female these pieces are less distinct, anal end emarginate; this latter character is hard to detect in living active specimens, being somewhat obstructed by the thick pubescence. The eighth or anal sternite in both sexes is retracted into the abdomen. In the male this sternite has two loosely connected chitinized shields covering the oedagus and anus; just dorsad of this shield another sclerite gives further protection to the oedagus, in the form of a transparent sheath (outlined with rather strong decurved chitinized margins that are recurved and divided at apex) just ventrad of the oedagus, which is slender and obtusely pointed. Length of vasa deferentes, 0.23 millimeter; length of oedagus, 0.34 millimeter. In the female this sternite is firm and more compact. It includes both the anus and the ovipostor. The anus bears a separate shield that is flanged ventrally through which the ovipositor is guided. The oviposter is long, about 2.37 millimeters, slender and flat with the exception of the apex which is slightly enlarged, subcylindrical, and bears a few rather rigid irregular setæ; the apex consists of about 0.27 millimeter of the ovipositor, including the 0.04 millimeter palpi at the terminal. Between the palpi the terminal is bilobed.



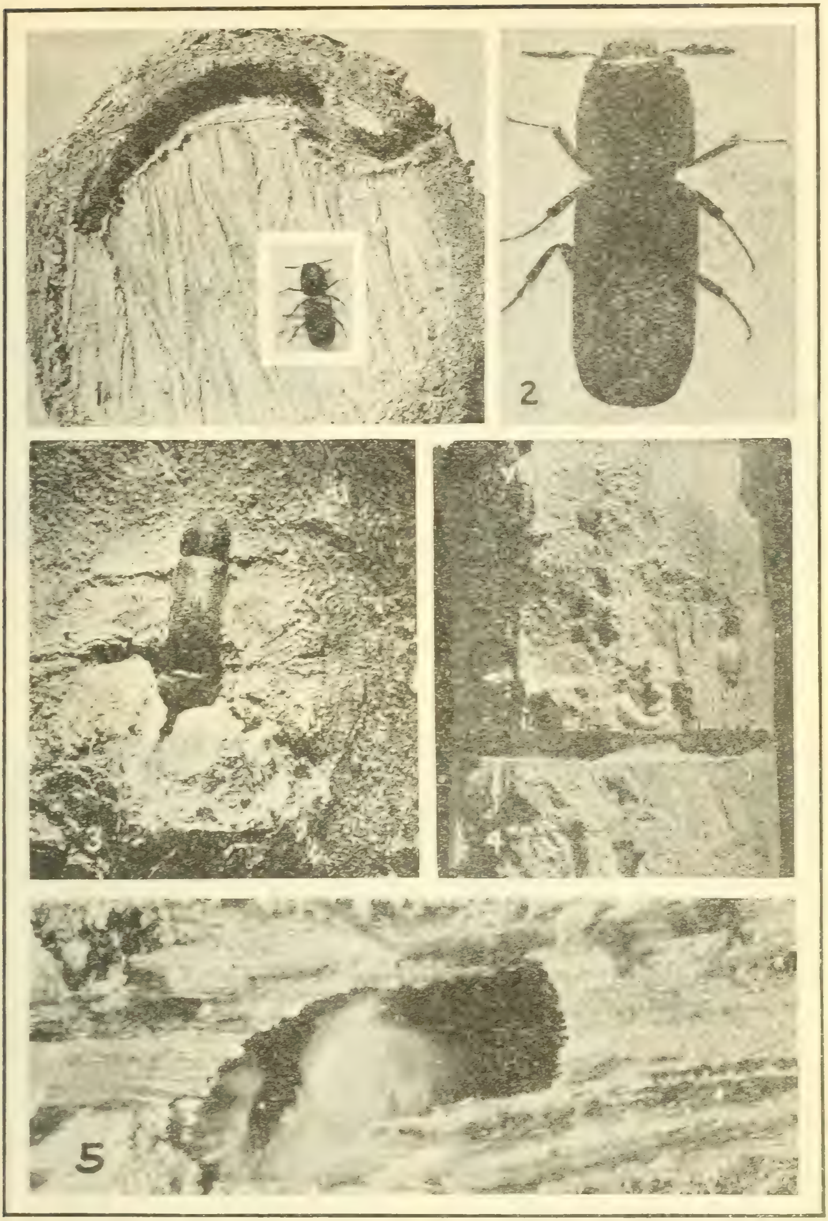
THE LEAD-CABLE BORER (SCOBICIA DECLIVIS).

FIGS. 1-7 and 9-12.—First-stage larva. FIGS. 13-15.—Second-stage larva. FIG. 16.—Mature larva. FIG. 8.—First-stage larva of *Lyctus* sp.: Posterior end of ninth abdominal segment with two cerci, oblique view from behind. FIG. 1.—Lateral view. Natural length, 0.75 millimeter. FIG. 2.—Antenna: *a*, Antennal joint; *b*, basal ring; *c*, supplementary joint; *d*, basal membrane. FIG. 3.—Labrum and clypeus, dorsal view: *cl*, Clypeus. FIG. 4.—Antenna, epipharynx, and mouthparts: *a*, Dorsal toothlike thickening of mandible; *b*, ventral toothlike thickening of same; *c*, thin chitinous wall between *a* and *b*; *d*, flat inner surface; *ep*, epipharynx; *m*, mentum; *ma*, maxillary articulating area; *sm*, submentum. FIG. 5.—Maxilla: *l*, Inner lobe represented by stylus-like chitinization; *g*, outer lobe; *1*, basal joint of maxillary palp; *2*, apical joint of same; *3*, tactile papillae. FIG. 6.—Labium: *li*, Ventral side of ligula; *1*, basal joint of labial palp; *2*, apical joint of same. FIG. 7.—Tail spur, outline seen from below. FIG. 9.—Lateral view. Natural length, 0.75 millimeter. FIG. 10.—Skin with prothoracic leg (I). FIG. 11.—Skin with mesothoracic leg (II). FIG. 12.—Skin with metathoracic leg (III). FIG. 13.—Lateral view. Natural length, 0.56 millimeter. Drawn with same magnification as Figure 9. FIG. 14.—Right mandible, showing its interior or biting surface. FIG. 15.—Ventral mouthparts: Details of ventral surface. FIG. 16.—Lateral view. Natural length, 10 millimeters. All figures drawn by Adam G. Böving, except Figure 8, which is by T. E. Snyder, and Figure 16, which is by Miss E. Armstrong.



THE LEAD-CABLE BORER (SCOBICIA DECLIVIS).

Morphological details of mature larva. FIG. 17.—Dorsal surface of head: *e*, Epistoma; *es*, epicranial suture, dorsal part. FIG. 18.—Lateral surface of head. FIG. 19.—Ventral surface of head: *es*, Epicranial suture, ventral part; *h*, hypostoma (see arrow; letter *h* placed in triangular continuation of hypostoma); *tb*, tentorial bridge, partly overlapped by presternal part of cervical membrane. FIG. 20.—Dorsal surface of maxillæ, ligula, maxillulæ, and hypopharynx: *hyp*, Hypopharynx; *li*, buccal side of ligula; *mxl*, maxillular area with longitudinal series of short setæ; *hyp*, hypopharynx with sling-shaped chitinization (*hr*) shining through surface. FIG. 21.—Anterior surface of head: *p*, Pleurostoma. FIG. 22.—Tentorium, ventral surface: *ta*, Tentorial arm; *tb*, tentorial bridge. FIG. 23.—Dorsal surface of left mandible. FIG. 24.—Longitudinal section of inner wall of mandible: *bm*, Thickening of basal margin; *g*, globular enforcement of posterior portion of wall. FIG. 25.—Left mandible, showing base with marginal thickening which carries trapeze-shaped chitinization; dorsal wall with fossa mandibularis; inner wall with anterior cavity, posterior thickening, and intermediate portion. FIG. 26.—Left mandible: Inner or buccal surface. FIG. 27.—Ventral surface of right maxilla: *c*, Cardo, showing its entire surface; *g*, outer lobe of mala (galea?); *l*, inner lobe of mala (lacinia), showing the small membranous part and the stylus-like chitinization; *pg*, palpiger; *st*, stipes. FIG. 28.—Antenna, clypeus, and labrum, dorsal surface. FIG. 29.—Ventral mouthparts, ventral surface: *li*, Ligula; *m*, mentum; *ma*, maxillary articulating membrane; *sm*, submentum; *st*, stipes of left maxilla; *stl*, stipes labii. FIG. 30.—Exterior surface of distal end of left prothoracic leg: *s*, Spine; *t*, claw-shaped tarsus; *ti*, tibia. FIG. 31.—Epipharynx: *er*, Epipharyngeal rod. FIG. 32.—Prothoracic spiracle. All figures, greatly enlarged, drawn by Adam G. Böving.



THE LEAD-CABLE BORER.

FIG. 1.—Female beetle in typical egg or parent gallery of host tree. Note a slight return toward the surface after entrance is secured. Enlarged about twice. Insert, beetle, enlarged about twice. FIG. 2.—Dorsal view of beetle, enlarged $8\frac{1}{2}$ times, showing rugosities on prothorax, and tibial spurs. FIG. 3.—Pair of beetles mating at entrance of egg gallery. Note elytral tip of female, just visible. The normal time for copulation seems to be shortly after the female has constructed her entrance gallery. Enlarged about $3\frac{1}{2}$ times. FIG. 4.—View of portion of parent or egg gallery, showing larval mines and a few larvæ on either side. These larvæ are probably from another egg gallery or returning toward their own gallery. Enlarged about $1\frac{3}{4}$ times. FIG. 5.—Lateral view of larva in mine of host tree. Note the distance left clear between larva and blind end of mine, this space being used by the larva in reversing; also dark area on chitinized line of prothorax. Enlarged about $10\frac{1}{2}$ times. Photographs by R. D. Hartman.

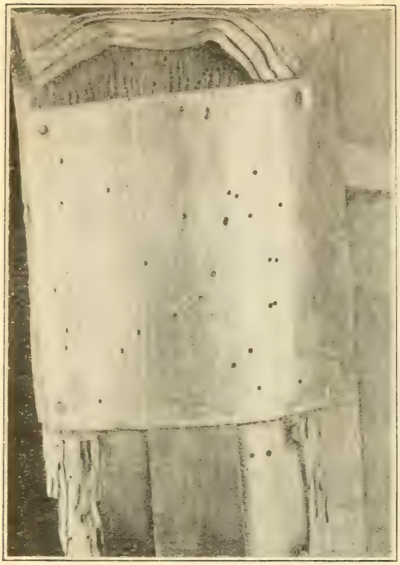


FIG. 1.—Infested section of oak covered with alloys and building paper in layers, but with narrow strip of sheet steel that was placed between layers of lead alloy and top layer of alloy removed. Shows beetles in holes where they were stopped by steel. Photograph by H. E. Burke.

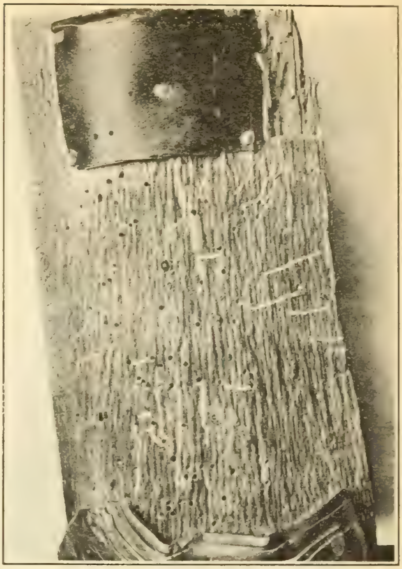


FIG. 2.—Section of infested oak with all the layers of alloy removed, showing how many of the beetles attempted to escape from the sides instead of boring through the alloys. Photograph by H. E. Burke.

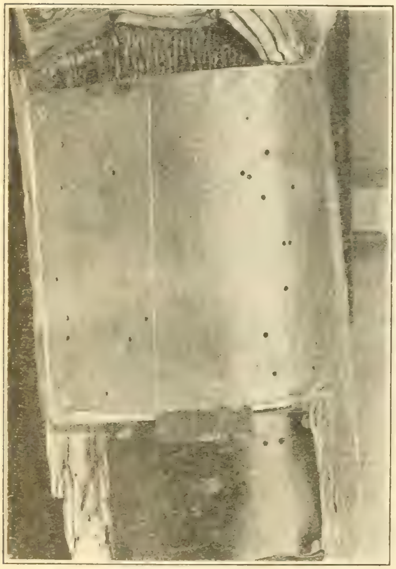


FIG. 3.—Infested section of oak covered with alloys and building paper in layers. Beetles have emerged through all except where narrow strip of sheet steel was placed between layers of lead alloy. Photograph by H. E. Burke.

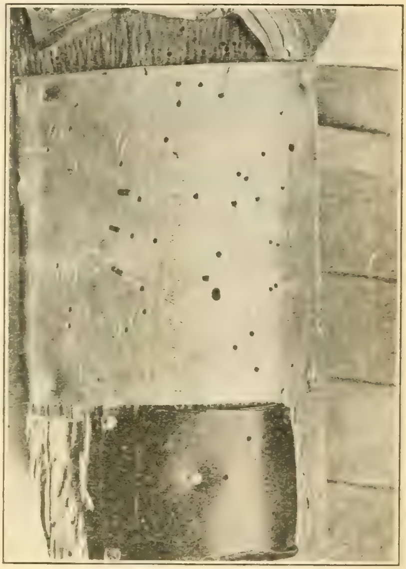


FIG. 4.—Same as Figure 1, except that next layer of alloy has been removed. The larger hole was made by the round-head borer *Xylotrechus nauticus*. Photograph by H. E. Burke.

THE LEAD-CABLE BORER.

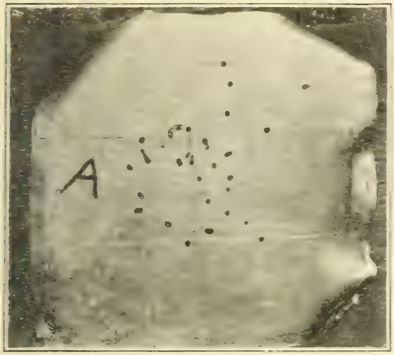


FIG. 1.—Sheet of lead alloy which was tacked over infested section of oak. Area between the lines marked *A* was covered with a strip of zinc which prevented the beetles from emerging. (Table 1, No. 26b.) Photograph by H. E. Burke.

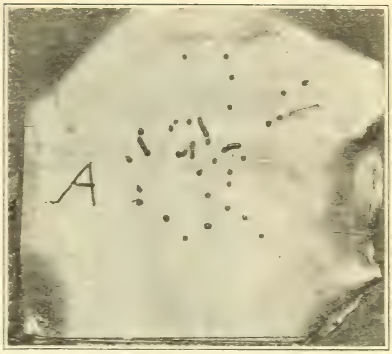


FIG. 2.—Sheet of lead alloy just under the preceding. Shows how the beetles mined to the side when they were stopped by the zinc. (Table 1, No. 26b,) Photograph by H. E. Burke

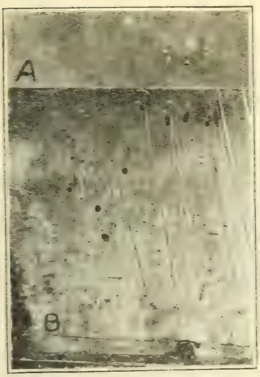


FIG. 3.—*A*, sheet of lead alloy which was covered by the sheet of zinc, *B*. Most of the beetles were unable to penetrate the zinc and stopped in *A*. One, marked *A* on sheet *B*, did penetrate the zinc. (Table 1, No. 25b.) Photograph by H. E. Burke.

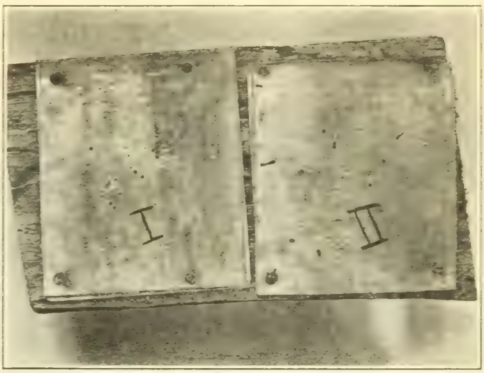


FIG. 4.—Sheets of lead alloys tacked over infested wood. *I* was covered with a sheet of lead carborundum coated on the upper or outer side. It did not seem to stop the beetles at all. Note clean-cut holes. *II* was covered with a sheet of lead carborundum coated on the inner side next to it. It seemed to stop most of the beetles. Note how they mined to the side in attempting to escape boring through it. (Table 1, Nos. 2a, 2b.) Photograph by H. E. Burke.

THE LEAD-CABLE BORER.

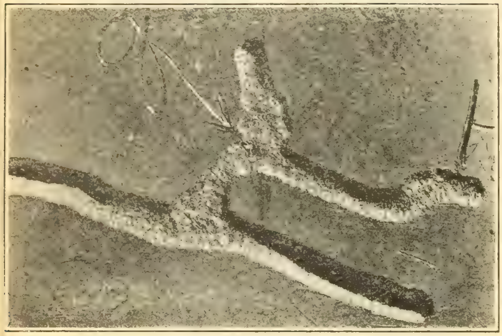


FIG. 1.—Section of lead showing the branched minings and mandibular impressions of two beetles. This was the underside of the second layer of lead, which was rolled unevenly and permitted the light to penetrate; thus the minings were irregular. Enlarged $1\frac{4}{5}$ times. (Table 2, No. 4.) Photograph by R. D. Hartman.

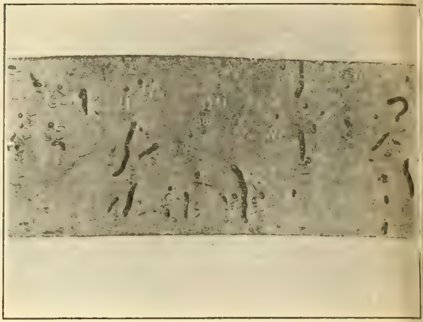


FIG. 2.—First layer of tin-coated lead *down* after being removed from infested section, showing 58 attempts, of which 24 were successful, in penetrating at least the first thickness. In many cases where the beetles attempted to escape between the section and the lead, they mined more in the lead than those that penetrated several thicknesses. One-fourth natural size. (Table 2, No. 52.) Photograph by R. D. Hartman.

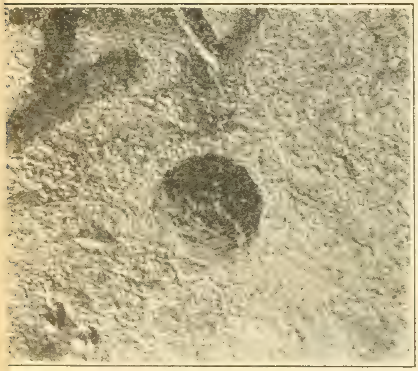


FIG. 3.—Typical beetle mine or single exit burrow in lead sheathing, enlarged $6\frac{1}{4}$ times. Beetle had mined about two-thirds through the sheathing. Photograph by R. D. Hartman.

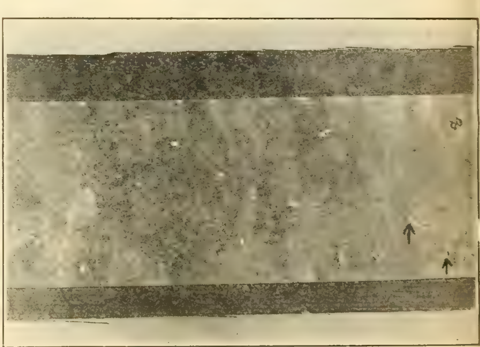


FIG. 4.—First layer of sheet zinc after being removed from infested section, showing 31 attempts, of which 2 were successful, in penetrating one thickness. These are designated by arrows. Three-tenths natural size. (Table 2.) Photograph by R. D. Hartman.

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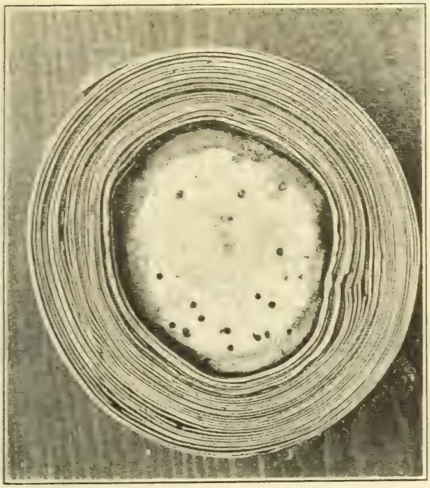

FIG. 1.—Method of wrapping infested oak with lead sheathing to determine number of thicknesses beetles are able to penetrate in emerging. Larval mines in wood and emergence holes of beetles in end of section. (Table 2, No. 55a.) Photograph by H. E. Burke.

FIG. 2.—Infested section of oak wrapped with lead alloy to determine number of thicknesses o flead penetrated by beetles in emergence. Method of wrapping also shown. (Table 3, No. 62.) Photograph by H. E Burke.

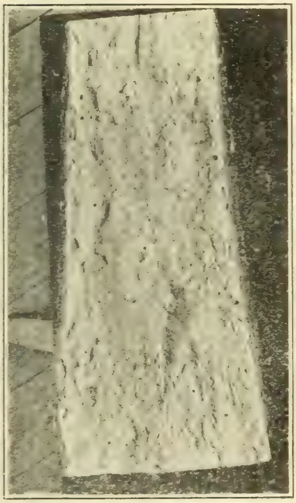

FIG. 3.—Work of beetle and larvæ in infested section of live oak. Larval mines and egg galleries. Longitudinal section. Photograph by H. E. Burke.

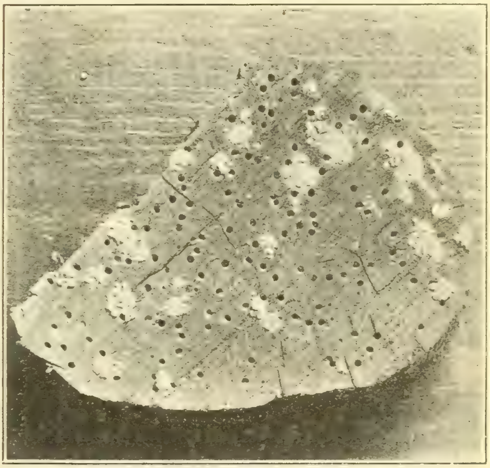

FIG. 4.—Cross section of infested oak, showing how the beetles sometimes emerge at the end of a section. Piles of dust indicate the work of the associated larvæ of the powder-post beetle *Lyctus planicollis*. Photograph by H. E. Burke.

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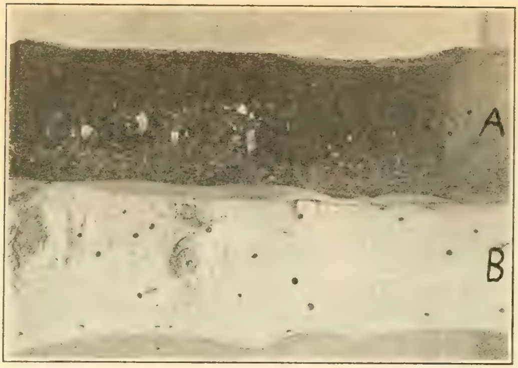

FIG. 1.—Two sections showing exit holes through varnished and painted areas. *A*=varnished section, to two-thirds of which was applied, at intervals before emergence, 5 coats of spar varnish. Forty-six beetles emerged through varnished area and 11 in unvarnished portion. *B*=white-paint enamel section, to three-fourths of which was applied one good coat of this paint. Thirty-seven beetles emerged through the painted area and 18 through the unpainted portion. These experiments, as in most cases, gave no material check to the beetles' emergence. One-half natural size. (Table 4, Nos. 5 and 12.) Photograph by R. D. Hartman.

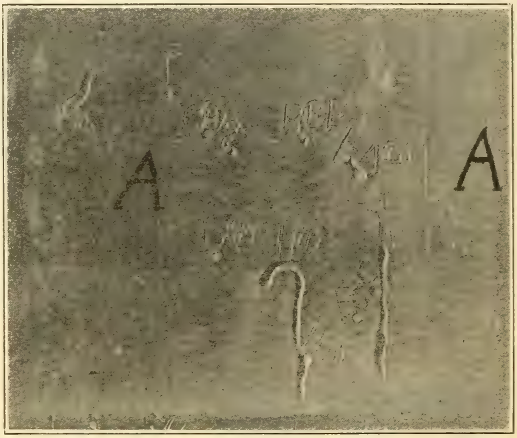

FIG. 2.—First thickness of lead sheathing after being removed from infested section. Previous to the lead being wrapped around the section about one-half of underside (*A*) was given 5 coats of spar varnish and 3 coats on infested section. Besides these numerous coats of varnish some beetles were able to penetrate 5 thicknesses of No. 3 lead and emerge. Two-fifths natural size. (Table 3, No. 56.) Photograph by R. D. Hartman

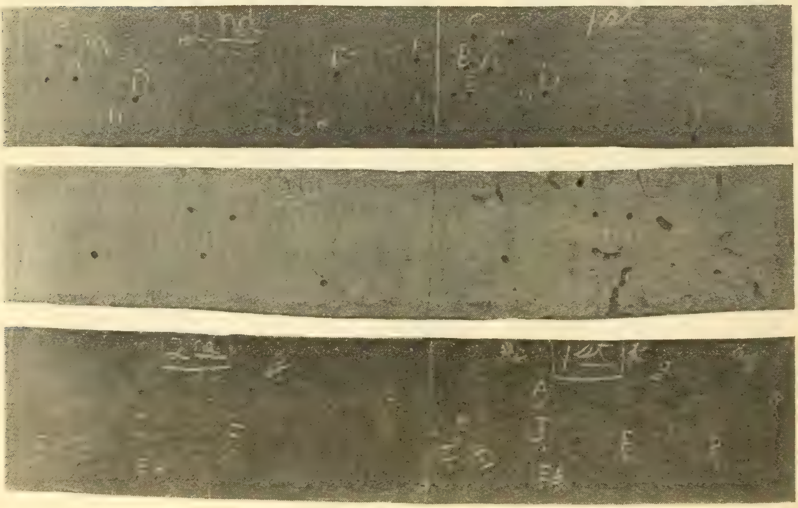

FIG. 3.—First two thicknesses of the three treated lead sheathings after being removed from infested section and manner in which beetles stopped as successive thicknesses were reached. Upper, embedded carborundum, where 17 beetles started in first thickness and 14 reached the second. Middle, tin-coated section, where 14 started in the first and 6 reached the second thickness. Lower, copper-coated section, with 16 and 12 penetrations, respectively. One-fifth natural size. (Table 2, Nos. 54, 54c, 54b.) Photograph by R. D. Hartman.

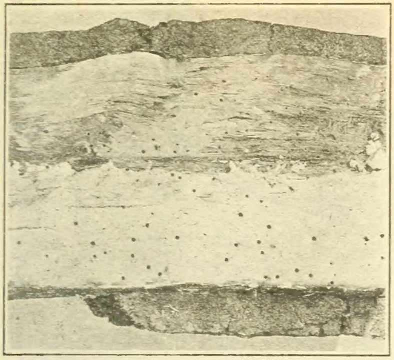

FIG. 1.—Section of infested oak with half of surface coated with tallow one-fourth inch thick. The beetle emerged through it without trouble as long as it was cold and hard. (Table 4, No. 8.) Photograph by H. E. Burke.

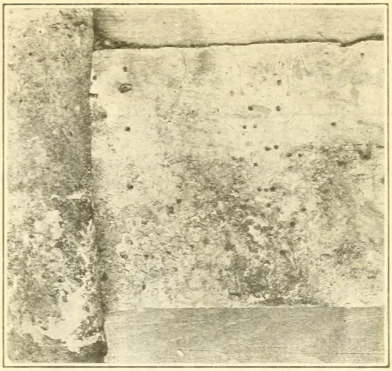

FIG. 2.—Part of roll of alloy, one-half of which was covered with tallow before it was rolled around infested wood. Holes are clean in untallowed section. A number of beetles were caught and died in the tallow when it was softened by the heat. (Table 3, No. 11.) Photograph by H. E. Burke.

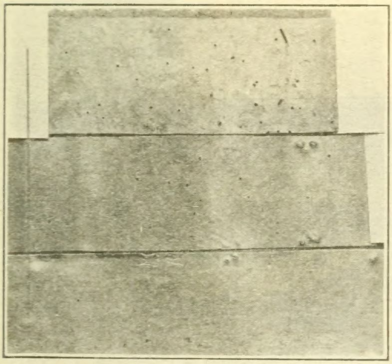

FIG. 3.—Layers No. 1, No. 2, and No. 23 of lead alloy rolled 27 times around an infested section of oak. Shows how the numbers of beetles penetrating the alloy kept diminishing as thicknesses increased. Thirty-seven went through the first, 14 through 12, and only 3 through 23 thicknesses; two of these went through the 24th but were stopped by the 25th. This was the greatest penetration obtained. (Table 2, No. 55a.) Photograph by H. E. Burke.

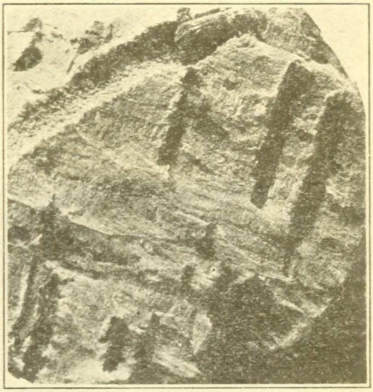

FIG. 4.—Beetle in gallery constructed in 30-mm. (1¼-inch) cork. A num er of other beetles were found in similar situations, the corks being used as stoppers to vials containing specimens in alcohol. Enlarged 2½ times. Photograph by H. E. Burke.

THE LEAD-CABLE BORER.

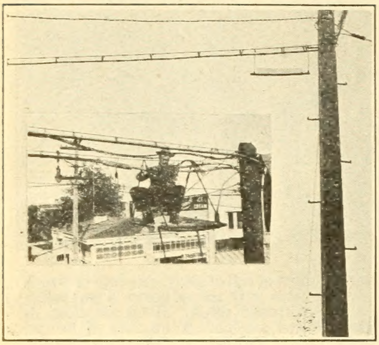

FIG. 1.—The upper cage incloses section of regular commercial cable and two suspension rings. The lower cage incloses section of dead cable used as a check. Insert, view showing repair of telephone cable made necessary by an attack of the lead-cable borer. Photograph by H. E. Burke and insert by R. D. Hartman.

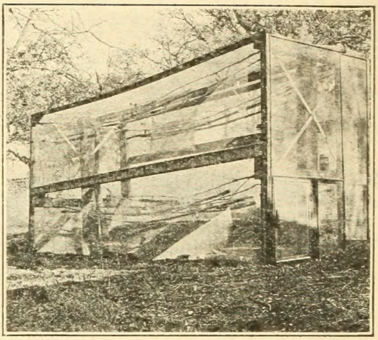

FIG. 2.—Test cables inside of cage, suspended by various types of rings. Some have direct current of electricity and some are without current; some were treated with various repellents and some were normal. Photograph by H. E. Burke.

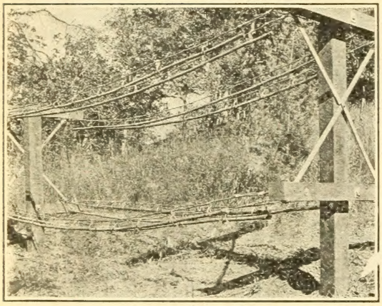

FIG. 3.—Cables on which cable tests were made. Photograph by H. E. Burke.

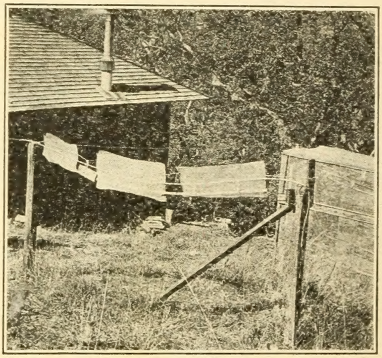

FIG. 4.—Section of cable and small cages built around it. These inclosed a section of the messenger strand, several suspension rings, and a section of the cable. Beetles were introduced into the cages to see if they would enter the cable. Photograph by H. E. Burke.

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